Public Document No. 33

TWENTIETH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

JANUARY, 1908.

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Approved by

The State Board of Publication.

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MASSACHUSETTS

AGRICULTURAL EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

ORGANIZATION.

Committee on Experiment Department.

CHARLES H. PRESTON, *Chairman.*
J. LEWIS ELLSWORTH.
WILLIAM H. BOWKER.
PERLEY A. RUSSELL.
SAMUEL C. DAMON.
THE PRESIDENT OF THE COLLEGE, *ex officio.*
THE DIRECTOR OF THE STATION, *ex officio.*

Station Staff.

CHARLES A. GOESSMANN, Ph.D., LL.D.,	*Honorary Director and Consulting Chemical Expert.*
WILLIAM P. BROOKS, Ph.D.,	*Director and Agriculturist.*
GEORGE E. STONE, Ph.D.,	*Botanist.*
JOSEPH B. LINDSEY, Ph.D.,	*Chemist.*
CHARLES H. FERNALD, Ph.D.,	*Entomologist.*
FRANK A. WAUGH, M.S.,	*Horticulturist.*
J. E. OSTRANDER, C.E.,	*Meteorologist.*
HENRY T. FERNALD, Ph.D.,	*Associate Entomologist.*
JAMES B. PAIGE, D.V.S.,	*Veterinarian.*
E. A. WHITE,	*Florist.*
HENRY J. FRANKLIN, B.Sc.,	*Assistant in Entomology.*
ERWIN S. FULTON, B.Sc.,	*Assistant Agriculturist.*
GEORGE H. CHAPMAN, B.Sc.,	*Assistant Botanist.*
EDWARD B. HOLLAND, M.S.,	*Associate Chemist* (research division).
ROBERT D. MACLAURIN, PH.D.,	*Assistant Chemist* (research division).
HENRI D. HASKINS, B.Sc.,	*Chemist in Charge* (fertilizer division).
PHILIP V. GOLDSMITH, B.Sc.,	*Assistant Chemist.*
JAMES C. REED, B.Sc.,	*Assistant Chemist.*
PHILIP H. SMITH, B.Sc.,	*Chemist in Charge* (feed and dairy division).
LEWELL S. WALKER, B.Sc.,	*Assistant Chemist* (feed and dairy division).
WILLIAM K. HEPBURN,	*Inspector.*
ROY F. GASKILL,	*Assistant in Animal Nutrition.*
CARL S. POMEROY, PH.B.,	*Assistant Horticulturist.*
EDWIN F. GASKILL, B.Sc.,	*Assistant Agriculturist.*
T. A. BARRY,	*Observer.*

REPORT OF THE DIRECTOR.

The work of the Massachusetts Agricultural Experiment Station during the past year has in the main followed the usual lines, but in most directions with constantly broadening scope and material increase in amount. The completion of Clark Hall, which will amply accommodate both the educational and the experimental work in the department of botany and vegetable pathology, will materially increase our facilities for investigation in this subject; but the interruption to work, made unavoidable by the necessity of moving and reinstalling the large amount of scientific apparatus and material, has necessarily reduced the amount of work in this department during the past year. The interruption has proved especially serious in connection with the study of problems relating to hothouse crops, as such work on the removal of department headquarters was necessarily discontinued in the old houses, and the new will not be completed until next spring. With this single exception, the work in all departments of the station has been prosecuted under conditions affording all the usual advantages.

Changes in Organization and in Staff.

The retirement from active administrative duties on the 1st of July of Dr. C. A. Goessmann, who from the date of its passage in 1884 has been charged with the execution of the fertilizer control law, and who was at the head of that branch of our chemical department carrying on general analytical and research work in connection with soils, manures, fertilizers and fertilizer problems, rendered reorganization in that department desirable. The chemical work of the station during the preceding eleven years had been divided between two distinct and entirely independent divisions, and carried on in separate laboratories. These divisions were known as the division of fertilizers and fertilizer materials and the division of foods and feeding; the first, as has been stated, under Dr. C. A. Goessmann, and the second in charge of Dr. J. B. Lindsey. It was believed that organization under one head would secure a number of important advantages, as compared with the existing plan. Most important among the advantages which we have aimed to secure in reorganization were the following: —

1. Greater administrative economy.
2. Reduction in cost of equipment, apparatus and work.
3. The more complete separation of control from ordinary experimental and research work, thus making possible more accurate determination of the costs of each.
4. Improved facilities for research work in chemistry, through the creation of a research division, to which certain specially qualified men should give their entire time.
5. A saving in the time required for certain classes of control and analytical work, through concentration of forces alternately upon different branches of such work.

The organization adopted in the effort to realize these advantages is as follows: —

Department of Plant and Animal Chemistry.

Chemist: J. B. Lindsey, Ph.D.
Associate Chemist: E. B. Holland, M.S.
(*a*) Research division: E. B. Holland, M.S.
(*b*) Fertilizer division: H. D. Haskins, B.Sc.
(*c*) Feed and dairy division: P. H. Smith, B.Sc.

Besides the heads of divisions, four other analytical chemists, an inspector who collects samples of feeds and fertilizers and inspects dairy apparatus, a general laboratory assistant and one or sometimes two clerical assistants, one of whom is an expert stenographer, are regularly employed. The department also employs an assistant, who cares for the animals used in nutrition experiments and digestion work.

The chemist has general supervision of the entire work, and is responsible therefor, but is relieved of details, and will give most of his time to research problems. The associate chemist assists the chemist if required, or in his absence acts in his stead. The associate chemist, whose duties as such are usually nominal, was placed at the head of the research division. Mr. Holland, who received this appointment, had already had much and successful experience in chemical investigation.

Mr. Haskins, who was put in direct charge of the fertilizer control, with responsibility to the chemist, has for several years been looking after most of the details of this line of work, owing to the advanced age of Dr. Goessmann, and is well qualified for the position, both by training and experience.

Mr. Smith, who, with responsibility to the chemist, was put in charge of the feed and dairy control division, had had several years of experience in such work, for which he had shown especial fitness.

No other changes in organization have been made during the year, and the station at the present time makes provision for the various lines of work in which it engages under the following departmental organization : —

Departments.	*Heads of Departments.*
Agriculture,	The Director.
Horticulture,	F. A. Waugh, M.S.
Plant and animal chemistry,	J. B. Lindsey, Ph.D. E. B. Holland, M.S., associate.
Botany and vegetable pathology,	G. E. Stone, Ph.D.
Entomology,	C. H. Fernald, Ph.D. H. T. Fernald, Ph.D., associate.
Veterinary,	J. B. Paige, D.V.S.
Meteorology,	J. E. Ostrander, C.E.

The only change in staff affecting a position of prominence in the station during the past year has been the retirement of Dr. Goessmann from active administrative duties at the head of the fertilizer division of our chemical department, already referred to. The station is fortunate in still being able to avail itself of Dr. Goessmann's services in the capacity of consulting chemical expert. His broad chemical knowledge and richly cultured mind and his long and varied experience render his advice of great value.

Dr. Goessmann at the age of eighty years looks back upon a career the memory of which must be to him a source of unusual satisfaction. It excites the profound admiration of all those familiar with his life, his character and his achievements. The exercises held at the college last commencement in honor of his eightieth birthday made strikingly manifest the esteem and affection in which Dr. Goessmann is held by the alumni. The beautiful piece of stained glass, symbolizing some of the more prominent features of his life and work, which was then presented to him, though a triumph of affection and the designer's art, all too inadequately serves to express these sentiments.

An attempt to present an estimate of the value of Dr. Goessmann's service to the station and to the State and to set forth his part in the advancement of agricultural science would be out of place in this report; and yet brief mention of some of the more prominent features of his connection with this institution and the great agricultural movements with which his name has been identified seems appropriate. Dr. Goessmann took the chair of chemistry in the Massachusetts Agricultural College within a year of the date when its doors were first opened to students (1867), and this chair he filled, though of late with relatively few classes, until his retirement in June. Coming to this position with the best university training which Europe at that time could afford, he brought to his position the university spirit and method, and almost from the first he made his department in effect an experiment station in agricultural chemistry. Before Massachusetts had a regularly organized experiment station, Dr. Goessmann had carried out a large amount of experimental work, the results of which were published in reports of the college and those of the secretary of the State Board of Agriculture, as well as in numerous agricultural and scientific periodicals. Among the most important of these early investigations are those carried out to determine the possibilities of the beet sugar industry in this country. He was a pioneer in this field, and in his numerous publications clearly outlined the essentials for success. Of more general importance to the country at large was Dr. Goessmann's work in relation to fertilizers. He determined the manurial value of a large number of refuse substances and by-products. To him belongs the honor of having suggested and taken the most important part in the passage of the first law providing for fertilizer control passed in the United States. This law has been worth untold sums to the farmers, in the protection against fraud which it has afforded, while so wisely was it shaped that under Dr. Goessmann's administration it has almost equally served the interests of honest manufacturers and dealers. Among other important investigations conducted by Dr. Goessmann prior to the organization of the experiment station should be mentioned his studies as to the effects of special fertilization upon the composition of fruits, his determination of the effect of girdling upon the quality of grapes, his recognition of the possible relation of fertilizers to certain plant diseases, his work in connection with the reclamation of the Green River salt marsh in Marshfield, his determination of some of the chemical changes taking place in ensilage and his chemical examination of sorghum and its products. He was associated with Stockbridge in his investigations which led up to the theory of special fertilization which bears the name of the latter, and in the study of the results of fertilizer applications through observations upon a lysimeter and analytical work connected therewith.

Upon the organization of an experiment station in Massachusetts, in 1882, Dr. Goessmann was made director. This position Dr. Goessmann held until 1895, when the Massachusetts or State station was combined with the station established as a department of the college under the Hatch act. At this time Dr. Goessmann was made honorary director, and was placed in charge of the chemical fertilizer and fertilizer control work, in which position he continued to serve the station with distinguished ability until his retirement the 1st of July last. He has taken with him in his retirement the good will, affection and esteem of all who have been associated with him, and all share in the hope that he will have many years yet of health, usefulness and happiness.

A number of minor changes in the station staff have been made during the year. These changes in many cases have been made necessary by the resignation of men who have left us for positions of greater responsibility and reward. The changes in staff have been as follows: —

E. Thorndike Ladd, M.S., promoted to the position of first assistant chemist, fertilizer division, in place of Edward G. Proulx, B.Sc., resigned.

Walter E. Dickinson, B.Sc., in place of E. Thorndike Ladd, promoted.

Carl S. Pomeroy, B.Sc., Ph.B., assistant horticulturist, in place of Charles P. Halligan, B.Sc., resigned.

George H. Chapman, B.Sc., assistant botanist, in place of Neil F. Monahan, B.Sc., resigned.

Upon the reorganization of the chemical department, which has been outlined, an additional chemist in the research division was employed. The successful candidate was Robert D. MacLaurin, Ph.D., who comes to us after thorough post-graduate courses in chemistry, and a brief but successful record in research work in the Rockefeller Institute in New York.

During the year Howard A. Parsons, dairy tester in the division of foods and feeding, has resigned, and during the past month we have received the resignations of Walter E. Dickinson and E. Thorndike Ladd, assistant chemists, both of whom resign to accept positions offering superior inducements. The positions thus made vacant have not as yet been filled.

The Mailing List.

Revision. — The revision of the mailing list referred to in the last annual report has been completed. It was found, as anticipated, that many of the addresses carried in the old lists were dead, either because of decease or removal of individuals. The postmasters throughout the State with rare exceptions willingly and heartily lent their aid in revising the lists. As soon as the revision was completed, stencils for use with the Elliott addressing machine were procured. The stencils have been arranged by post offices, which are placed alphabetically in the files, and under each post office the names are alphabetically arranged. As a result of this arrangement, several important advantages are secured: —

1. Publications as addressed can be readily made into bundles for the several post offices. This saves a great amount of time in handling and sorting at the local post office and costs us but very little additional labor.

2. Publications can be much more promptly sent out than was possible previous to this arrangement by post offices.

3. If desired, as for example, in case of an outbreak of injurious insects in a certain locality, bulletins or ciculars can be readily sent to that locality.

The addresses of parties outside of Massachusetts are arranged alphabetically under the several states and countries.

Mailing List. — On completion of the revision, it was found that the number of live addresses was as follows: —

Residents of Massachusetts, ...	14,612
Residents of other States, ...	1,720
Residents of foreign countries, ...	169
	16,501

In addition, the station uses the Washington mailing list, which includes the addresses of those engaged in agricultural college and experiment station work. The total number of addresses in this list is about 2,000.

The station also uses the following special lists for meteorological reports, libraries, newspapers and exchanges: —

Meteorological, ...	260
Libraries, ...	158
Newspapers and exchanges, ...	520

During the past year an effort has been made to secure the addresses of all prominent cranberry growers. These addresses have for the most part been secured by writing to chairmen of the boards of selectmen in towns in the cranberry district, and to these men, most of whom prepared the lists promptly and without charge, the thanks of the station are due. The number of addresses in this list is 1,505.

During the past year we have added substantially 1,000 addresses to our general mailing list. These additions have been made in response to direct requests, and without solicitation on our part.

Publications.

Our rapidly growing mailing list has already greatly increased the costs of publication, and these costs must inevitably continue to increase with the constant additions to our lists. The time is not far distant when additional money for publications will be required. During the past year the publications of the station have been as follows: —

Publications during 1907.

Annual report: —

Contains reports of the director, treasurer and heads of departments, with papers on a large number of miscellaneous subjects. 207 pages.

Bulletins: —

No. 112. The Examination of Cattle and Poultry Foods, J. B. Lindsey. 60 pages.

No. 113. Analysis of Manurial Substances and Fertilizers and Trade Values, C. A. Goessmann. 30 pages.

No. 114. The Oriental Moth: a Recent Importation, H. T. Fernald. 15 pages.

No. 115. Preliminary Report on Cranberry Insects, H. J. Franklin. 15 pages.

No. 116. The San José Scale, H. T. Fernald. 22 pages.

No. 117. Trade Values and Fertilizer and Soil Analyses, C. A. Goessmann and H. D. Haskins. 22 pages.

No. 118. Molasses and Molasses Feeds for Farm Stock, J. B. Lindsey, E. B. Holland and P. H. Smith. 32 pages.

Technical, No. 3. Blossom End Rot of Tomatoes, Elizabeth H. Smith. 19 pages.

Complete Index to Bulletins and Reports of the Hatch Experiment Station, from 1888 to 1907. 48 pages.

Circulars: —

No. 1. Cotton-seed Meal, J. B. Lindsey and P. H. Smith. 8 pages.

No. 2. Cut Worms, H. T. Fernald. 2 pages.

No. 3. The Apple Maggot or Railroad Worm, C. E. Hood. 2 pages.

No. 4. Wire Worms, C. E. Hood. 2 pages.

No. 5. Root Maggots, H. T. Fernald. 2 pages.

No. 6. The Lecaniums, or Soft Scales, C. E. Hood. 2 pages.

No. 7. Ants, C. E. Hood. 2 pages.

No. 8. Bulletins of the Agricultural Experiment Stations in Massachusetts. 13 pages.

No. 9. Rules relative to Testing Dairy Cows. 6 pages.

No. 10. Sampling and Sending of Fertilizers, Soils and Feed Stuffs for Free Examination. 3 pages.

No. 11. Chemical Analysis of Soils, Wm. P. Brooks. 2 pages.

The complete index to the publications of the Hatch Experiment Station was very carefully prepared. It includes many cross-references, and will be found exceedingly valuable in connection with complete files of station publications from 1888 to 1907, inclusive. This bulletin will be sent, on application, to parties having files sufficiently complete to make it valuable.

Circular No. 8 gives a complete list of all the bulletins published both by the State and the Hatch Experiment Stations, as well as by the Massachusetts Agricultural Experiment Station, up to the date of its issue in July last. In this list publications which are still available for general distribution are indicated.

The other circulars are for the most part designed for use in answer to correspondence in relation to subjects with which they deal. They cover subjects on which the station receives frequent inquiries, and do so much more fully than would be possible within the limits of a letter.

The annual report of the station is printed by the State, and furnished only in an edition of 6,000. It will not be possible, therefore, to send this report even to all Massachusetts citizens whose names are on our mailing lists. Fifteen thousand copies of this report are, however, furnished to the secretary of the State Board of Agriculture, and are bound with his report, so that it is hoped the report in this form may reach all those who desire it. This plan of publication and distribution must, it seems, mean that many parties in the State receive duplicate copies of our reports. Clearly this is not economy, but we are for the present constrained by a State law to the method of publication outlined. An effort will be made during the coming session of the Legislature to secure a change in the law affecting our publications.[1]

Bulletins and Reports available for Free Distribution.

The supply of many of our reports and bulletins available for free distribution has been exhausted, but those in the following list will still be furnished on application : —

Bulletins : —

No. 33. Glossary of fodder terms.
No. 34. Fertilizer analyses.
No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 64. Analyses of concentrated feed stuffs.
No. 68. Fertilizer analyses.
No. 76. The imported elm-leaf beetle.
No. 81. Fertilizer analyses; treatment of barnyard manure with absorbents; trade values of fertilizing ingredients.

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[1] Since writing the above report the Legislature has authorized the desired change.

No. 83. Fertilizer analyses.
No. 84. Fertilizer analyses.
No. 89. Fertilizer analyses; ash analyses of plants; instructions regarding sampling of materials to be forwarded for analysis.
No. 90. Fertilizer analyses.
No. 92. Fertilizer analyses.
No. 97. A farm wood lot.
No. 98. Inspection of concentrates
No. 99. Dried molasses beet pulp; the nutrition of horses.
No. 100. Fertilizer analyses; market values of fertilizing ingredients.
No. 102. Analyses of manurial substances and fertilizers; market values of fertilizing ingredients.
No. 103. Analyses of manurial substances; instructions regarding sampling of materials to be forwarded for analysis; instructions to manufacturers, importers, agents and sellers of commercial fertilizers; discussion of trade values of fertilizing ingredients.
No. 105. Tomatoes under glass; methods of pruning tomatoes.
No. 107. Analyses of manurial substances forwarded for examination; market values of fertilizing ingredients; analyses of licensed fertilizers collected in the general markets.
No. 109. Analyses of manurial substances forwarded for examination; analyses of Paris green and other insecticides found in the general markets; instructions regarding the sampling of materials to be forwarded for analysis; instructions to manufacturers, importers, agents and sellers of commercial fertilizers; discussion of trade values of fertilizing ingredients for 1906.
No. 113. Fertilizer analyses.
No. 114. The oriental moth; a recent importation.
No. 115. Preliminary report on cranberry insects.
No. 116. The San José scale.
No. 117. Trade values and fertilizer and soil analyses.
Technical Bulletin No. 2. The graft union.
Technical Bulletin No. 3. The blossom end rot of tomatoes.
Special Bulletin. The coccid genera *Chionaspis* and *Hemichionaspis*.
Index to bulletins and annual reports of the Hatch Experiment Station published previous to June, 1895.
Index to bulletins and reports, 1888–1907.
Annual reports for 1898–1907.

Of many of the other bulletins of the station, a few copies still remain. These will be supplied only to complete sets for libraries. Circular No. 8, which gives a complete list of bulletins published by this station, will be sent on application.

The co-operation and assistance of farmers, fruit growers and horticulturists, and all interested directly or indirectly in agriculture, are earnestly requested: Communications should be addressed to Massachusetts Agricultural Experiment Station, Amherst, Mass.

Asparagus Substation, Concord.

The work with asparagus in Concord, which is located on land leased from Mr. Charles W. Prescott, follows two distinct lines: (1) in co-operation with the Bureau of Plant Industry, of the United States Department of Agriculture, an effort to breed rust-resistant types of asparagus; (2) fertilizer experiments under the Adams fund in the effort to throw light upon the general question of the specific plant food requirements of this crop.

Breeding Experiments. — The Bureau of Plant Industry, through its agents in various parts of the world, has brought together a very large collection of varieties of asparagus. These have been drawn from all countries where the crop is grown. In most cases seed was procured. This seed was sown in a hothouse in Washington early last spring, and the young plants were sent in flats to Concord. This method of starting the plants was adopted in the belief that considerable time might thereby be saved. The number of varieties started was 36, but seed of several varieties was obtained from a number of sources, and 54 lots of seedlings were handled in this manner. The degree of success attending this method was only moderately satisfactory. The results varied widely with varieties, but in most cases there was a considerable percentage of loss, — greater no doubt than it otherwise would have been, on account of the extremely dry season. The young plants which survived made a fairly good growth. In addition to these varieties, our breeding plots now contain 35 other varieties, which have been brought together from various sources many of them having been collected by the Bureau of Plant Industry. Among the different varieties thus brought together in the same field may already be noted a very considerable variation in the apparent susceptibility to rust, and it may confidently be hoped that the objects in view in the experiment will ultimately, in large measure, at least, be attained.

Fertilizer Experiments. — The land selected for the fertilizer experiments lies in the Bedford Street district in the town of Concord. For a number of years previous to 1906 the field had been lying fallow, and was grown up with briers, small birches, weeds, etc. In preparation for the fertilizer experiments the field was cleared of brush and trees and plowed in the spring of 1906. It then received an application of fertilizers at the following rates per acre : —

Lime (tons),	[illegible]
Fine ground bone (tons),	1
Acid phosphate (pounds),	½
Muriate of potash (pounds),	600
Nitrate of soda (pounds),	350
[illegible]	150

These with the exception of the lime, were mixed, evenly spread and harrowed in. The lime was applied by itself. In order to subdue the witch grass and other weeds, the field was harrowed a number of times during the late spring, and on May 15 it was sown to buckwheat. The buckwheat made a heavy growth, and was plowed under when fully grown. The field was then harrowed and sown to winter rye. This was plowed under in the early spring of 1907, and the asparagus set. The field is laid out in forty twentieth-acre plots, separated by dividing strips 5 feet and 1½ inches in width.

The dimensions of the plots are 129 feet by 16 feet 10½ inches. Each plot contains five rows. Each dividing strip contains one row set in the middle. The distance between plants in the rows is 2 feet 6 inches. The plants were raised by Mr. Frank Wheeler of Concord, and were from seed of the Giant Argenteuil variety, specially selected by Mr. Wheeler on account of apparent vigor and capacity to resist rust. These plants were exceptionally large and strong, and one year old at the time of setting. Practically every plant started, and the growth throughout the season was remarkably strong. Many of the plants attained a height in excess of 6 feet. All the details of the work were superintended or carried out by Mr. Charles W. Prescott, to whose skill and faithful attention, in connection with the thorough preparation which the land had received, the fine growth of the plants must be largely attributed. Numerous interesting variations in growth on the different plots were noted during the season, but it is yet too early to present the details of treatment, or to discuss the effects of the different fertilizer applications.

Cranberry Substations.

The station is carrying on work with cranberries along two distinct lines and in two different localities: (1) the study of cranberry insects in Wareham; (2) fertilizer experiments with cranberries in Falmouth.

Work on Cranberry Insects. — The station was fortunately able to command once more the services of Mr. H. J. Franklin for the study of problems connected with cranberry insects. Mr. Franklin spent the entire season, from the middle of April to the middle of October, in the cranberry district, most of the time in the town of Wareham. As the result of the season's work, our knowledge of cranberry insects has been greatly extended at numerous points, and the tentative conclusions reached as a result of the first season's work have been in many cases confirmed. A bulletin presenting the results of the first season's work, and containing advice as to the treatment to be adopted for the prevention of injury from the more important cranberry insects, has been issued during the year. This has been sent to all cranberry growers whose addresses we were able to obtain, — about 1,500. It has been found that the injury due to many insects can be for the most part prevented by a thorough destruction of vegetation around the shores of the bog, and suitable control of the water in flooding. Methods of spraying have been found to be fairly effective in some cases. The bulletin on cranberry insects, which gives all details, can still be furnished on application.

Fertilizer Experiments. — The fertilizer experiments in Falmouth are located in what is known as the Red Brook bog, belonging to Mr. N. H. Emmons of Boston and Falmouth. The present is the second season that these experiments have continued, and results which are believed to be of considerable significance have been obtained. The possibility of making exact comparisons between different fertilizer treatments has been in considerable measure reduced, owing to the unfortunate breakage during last winter of one of the dikes, thus exposing a portion of the plots used in fertilizer experiments throughout the winter, while another portion of the plots was under water. It is not best, therefore, to undertake a discussion of the results in detail at this time. The following conclusions, however, appear to be warranted: —

1. The use of nitrate of soda greatly stimulates the growth of vines, and on bogs where vine growth is naturally free, this fertilizer should be used sparingly if at all. It has been noted, however, that the size of the berries is considerably increased wherever nitrate has been applied.

2. The application of acid phosphate appears to favor early maturity of the fruit, accompanied apparently by decrease in size. It would be premature to assert that this fertilizer element should not be used at all, but the indication is that the quantity needed is relatively small.

3. Among the fertilizer elements applied, the potash appears to have exerted the most favorable influence on the yield of fruit. Not only has it apparently increased the quantity, but it seems highly favorable to the development of a bright color, which gives the fruit an unusually attractive appearance. The fruit on the plots to which muriate of potash and acid phosphate were applied was characterized by experts as exceptionally solid and heavy, as well as of fine appearance.

4. The application of lime appears to have been unfavorable to fruitfulness.

Substation for Orchard Experiments.

Plans have been laid for extensive orchard experiments which will extend over a long period. A six-acre orchard of Baldwin trees set six years ago has been leased for ten years. The location is on the Bay Road in the southern part of the town of Amherst, on the farm of Myron C. Graves. The soil conditions throughout the entire tract appear to be exceptionally even for a tract of such size in this State, and it is believed the orchard affords very exceptional advantages for fertilizer, cover-crop and cultural experiments, which are the principal types of work in view.

Department Reports.

The reports of the heads of the different departments of the station will be found in later pages. The report of the agriculturist is elsewhere briefly summarized.

Department of Horticulture. — The report of the department of horticulture includes papers upon three distinct subjects: —

1. Notes on the propagation of apples. The experimental work upon which this paper is based was carried on with dwarf trees. The principal object of the experiment was to determine the influence of the scion on the character of the tree. The variety reported upon in greatest detail was the Baldwin, which was grafted upon three different stocks: the ordinary apple; Doucin; and Paradise. The method of measurement adopted shows a distinct influence apparently due to the variation in scion. The trees on the Doucin stocks were more uniform in shape and taller than those on the Paradise stocks; the trees on Paradise stocks were much stockier than on Doucin; while those on Doucin stocks were in turn much stockier than those on the ordinary stocks.

2. The physiological constant for the germination stage of cress. The methods which have been used in investigations for the determination of physiological constants are briefly outlined. The method reported upon, which is original, is described and compared with the earlier methods. The results with cress are reported in detail.

3. Variation in peas. This paper presents the results obtained by careful observations, and includes tabular records of a large number of observations which are carefully averaged. The results obtained are fruitful in suggestions as to the principles which should be followed in selection in breeding for improvement in any given direction.

Department of Plant and Animal Chemistry. — The report of the chemist presents first a numerical statement of the amount of analytical work accomplished during the year. This makes it apparent that the demands upon the station for work of this character are rapidly increasing.

The chemist in charge of the fertilizer control work, H. D. Haskins, reports the analysis of 45 more brands of fertilizers in connection with such work than in 1906. Three hundred and fifty-eight samples in all have been analyzed and nearly 500 collected. Forty-one per cent. of the samples analyzed proved to be below the guaranteed composition in some one or more of the fertilizer elements, but in many cases the deficiency in one element was made up by an excess in one or more of the others. Twenty-one samples of complete fertilizers showed a commercial shortage varying from 79 cents to $13.50 per ton. This section of the report of the chemist presents complete tabular statements, showing the extent to which the fertilizers analyzed equaled or fell short of the guarantees.

The next section of the report presents an account of the execution of the feed law. Samples of feeds analyzed, with the single exception of cotton-seed meal, the quality of which was unusually poor, were found in general to be substantially as guaranteed. The report calls attention to the large amount of analytical work which is done without charge for private individuals in determining the quality of samples of milk and feeds. The results of the execution of the dairy law are briefly presented: 6.62 per cent. of Babcock glassware tested was condemned on account of inaccuracy; of the Babcock machines inspected, 37 in all, 2 were condemned.

The chemist calls attention to the great increase in the amount of work connected with the carrying out of official tests of pure-bred cows. Such tests are now conducted with animals of the Jersey, Guernsey, Holstein-Friesian and Ayrshire breeds. During the past year thirty-five yearly records and seventy records for shorter periods have been completed. Sixty-three cows are now undergoing tests. This work consumes a large amount of time, and, while the station is reimbursed for its money expenditure, it is found to be somewhat of a burden. The work is, however, without doubt important and useful, and until it is provided for in some other way the station will continue to supervise it.

The report of the chemist briefly presents the results of experiments completed with a view to determining the value for different classes of live stock of molasses and molasses feeds. He does not regard molasses as possessing advantages for dairy cows over the more common feeds. For fattening cattle, the use of about 3 pounds daily can be recommended. For horses, a moderate amount of molasses is found to be useful as an appetizer and tonic; and the same is true for pigs. Molasses feeds are in general found to be rather high in price as compared with possible home mixtures, and would seem to possess no advantages as compared with such mixtures.

The results of experiments to determine the effects of soy beans minus the oil and of soy bean oil as food for dairy cows are presented. It was found that the meal, although exceptionally rich in protein, does not change the proportion of the different ingredients of milk. The oil temporarily increases the proportion of fat, and is found to affect the quality of the butter to a considerable extent, and on the whole unfavorably.

The report calls attention to experiments which are in progress on the effects of fat on milk secretion, and refers briefly to research work with soils from the different plots in Field A.[1]

It has been found that feeding molasses in large quantities depresses the digestibility of other foods used with it.

A section of the report of peculiar interest at this time, when the question of milk standards interests so many, deals with the chemical composition of milk. The average composition of the milk of most of the different prominent breeds, based upon a large number of analyses in different sections of the country as well as in foreign countries, is presented.

The effects of fat upon the composition of milk and butter fat and upon the consistency of butter are discussed by Dr. Lindsey. His experiments have shown that neither the proteid nor carbohydrate groups of nutrients when fed in normal amounts have any noticeable effect upon the proportion of different ingredients, nor on the character of butter fat. Any changes which occur as the result of variations in feed are usually consequent upon the kind and quantity of oil contained in the feeds used. Dr. Lindsey has found that when the feeds contain vegetable oils in excess of normal amounts the butter is soft. He finds that the flavor of butter depends primarily on cleanliness, the stage of lactation of the cow, the skill and care of the butter maker and the separator used.

[1] For an account of the experiments on Field A, see report of the agriculturist, page 32.

The concluding section of the report of the chemical department is a paper by E. B. Holland, on a "Standard for Babcock Glassware." This paper presents a summary of the results of the tests of Babcock glassware carried out at the station since the passage of the dairy law in 1901. A standard for such glassware is proposed and carefully drawn, and rules for testing are presented. The standard and rules proposed by Mr. Holland have not yet been officially sanctioned by the American Association of Agricultural Chemists, but both have met the approval of Dr. Babcock, and they will probably be adopted.

Department of Botany and Vegetable Pathology. — The report of Dr. Stone, the head of the department of botany and vegetable pathology, contains papers upon a considerable number of important topics. Of especial interest is Dr. Stone's report concerning methods of separating light and inferior seeds and dirt from commercial or home-grown samples of seeds. The apparatus perfected in the department for this work shows much ingenuity in design, and the work is accomplished with great rapidity and accuracy. The methods used here are especially important for such seeds as tobacco and onions. As a result of the rejection of the inferior seed, a better stand of plants, substantially all of which, coming from sound, heavy seeds, are strong, healthy and disease-resistant, is obtained than is possible when commercial samples are planted. Work of this character is for the present done without charge. There has been a considerable increase in the number of samples sent in to be tested for germination. This work also is done for the present without charge.

The report calls attention to the unusual extent to which sun scald and sun scorch have prevailed among different varieties of trees. These troubles appear to be due primarily in many cases to the loss of a considerable proportion of the fibrous rootlets, which the botanist believes has been due to the excessively cold winters of a few years ago; and these troubles have shown more largely than usual during the past summer on account of the severe drought which prevailed. The extensive defoliation of many species of trees, notably elms, in the late summer or early fall, is believed to have been the result of the same cause.

The report calls attention to two apparently new diseases: one affecting asparagus, and apparently caused by a species of fusarium; and another affecting the peony, the cause of which has not been determined. No remedy for either of these troubles can at present be suggested.

During the past year the botanist has made careful comparisons between a number of combinations of fungicides and insecticides for potatoes. These experiments were carried out in connection with fertilizer work of the agricultural department which is designed to throw light upon the relative value for different crops of seven different potash salts.[1] There was little or no blight during the season, and all of the combinations tried seemed to possess nearly equal merit as insecticides. From the standpoint, however, of their ability to adhere to the foliage and their qualities in other respects, the botanist ranks the different combinations used in the following order: —

1. Soda bordeaux and Paris green.
2. Bordeaux and sodium benzoate.
3. Bordeaux and disparene (arsenate of lead).
4. Bordeaux and Paris green.
5. Copper phosphate and disparene.

In connection with the variation in fertilizers for the potato crop in this series of experiments,[1] an important influence on the prevalence of scab was noted. The proportion of badly scabbed tubers was much greater where potassium-magnesium carbonate was the source of potash than on any of the other plots.[2] The proportion of scabby tubers was smallest where the muriate and nitrate were the potash salts employed; but the difference between the proportion of scabby tubers on these fertilizers and on the other potash salts was relatively small.

The report of the botanist discusses mosaic diseases of tobacco and the tomato. He finds an important difference between the two diseases in two respects. Healthy tobacco

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[1] For a full account of these experiments, see report of the agricultural department, page 39.

[2] The fact that scab is more apt to prove serious in soils which are alkaline has been frequently noticed. The potash-magnesia carbonate is a strongly alkaline fertilizer. Dr. H. J. Wheeler has frequently called attention to this point in reports and bulletins of the Rhode Island Experiment Station and elsewhere.

plants set in soil which contains decaying rootlets of diseased plants usually become affected with the disease. In the case of the tomato, a similar result does not follow. The report gives an account of methods tried for the purpose of determining the cause of the mosaic disease in the tomato. The botanist believes his experiments show that the disease is not caused by an excess of any of the fertilizer elements. The mosaic disease of tobacco may be so caused. The disease can be produced in tomatoes by severe pruning, and is at least associated with a deficiency of both the soluble and insoluble forms of catalase in the foliage.

The report of the botanist includes a suggestive paper on the factors which underlie susceptibility and immunity to disease in plants. This paper emphasizes the necessity of as full and perfect knowledge of the conditions essential for perfect development as possible, and advances the view that when our knowledge is sufficiently complete at this point it will be found possible in large measure to avoid many diseases which at present often prove highly destructive. We find the highest development of cultural methods among American gardeners and hothouse men. In the hothouse, where the climatic conditions are largely under control, there is but little trouble from disease when the conditions are fully understood and the management skillful. In the case of out-of-door crops, control of the climate being impossible, we may not be able so fully to avoid disease ; but even with such crops, the most skillful adaptation of soil, manure and culture to the requirements of the crop will in large measure accomplish the same result.

Entomological Department. — The report of this department presents first a summarized statement showing the kind and amount of the work of the year. Brief accounts are also presented of some of the leading lines of experimental work. One of the most important of these is for the determination of the resistance of different crops to fumigation with hydrocyanic acid gas. These experiments are now complete for the cucumber, and similar tests for muskmelons have been begun.

Brief mention is made of experiments for the control of cabbage, turnip and onion maggots, concerning which, owing to causes beyond control, no definite results can yet be presented.

One of the most important lines of experiment during the past year has been the effort to determine the best methods of controlling thrips, which so often cause the blight of the onion. Spraying with kerosene emulsion appears to be the most promising method. The principal difficulty appears to be the production of a machine which will spray a number of rows at once in a sufficiently thorough manner to destroy most of the insects. No perfectly satisfactory machine has yet been invented.

The report makes brief mention of experiments to determine better methods of destroying the San José scale, and the work with cranberry insects at Wareham. Further observations on the oriental moth are presented, and fortunately these indicate that this insect is not likely to become a serious pest. Attention is called to the fact that investigations have been begun to determine the exact geographical distribution of injurious insects. This work would seem to be particularly important, as Massachusetts is close to the northern limit of the distribution of some and near the southern limit of others. The report concludes with a presentation of observations upon the insects of the year.

Veterinary Department. — The report of the veterinarian presents an account of two serious outbreaks of disease among poultry. The first of these was European chicken cholera, which was found in two flocks. The identity of the disease was proved by careful microscopic investigations and inoculations. The owners of the affected flocks were promptly informed of the serious character of the disease, and, co-operating heartily with the veterinarian as they did, its prompt suppression was effected, and fortunately the disease did not spread from these flocks, which might easily have been centers of infection.

The other outbreak was found in a flock of chickens raised in brooders upon bare, sandy soil. It produced serious lesions of the feet and legs, and invariably proved fatal. The disease was found not to be infectious in character, and promptly disappeared when the chickens were moved to a more fertile location, where the growth of vegetation afforded some shade. It appears to have been due to the effects of the intense sunshine, aggravated by the character of the soil upon which the chickens were kept. The disease did not affect chickens brooded under hens, although kept on the same kind of soil.

Meteorological Department. — The report of the head of this department calls attention to a number of important improvements which have been made in the equipment of the department during the past year. One of the most important of these is the setting up of apparatus over one of the manholes of our heat distribution system for melting snow as it falls. By means of this apparatus it will be possible to secure a more accurate record of the total precipitation, while by means of connections with recording apparatus in the office of the department the time of beginning and ending of storms can be determined with much exactness.

WM. P. BROOKS,
Director.

ANNUAL REPORT

Of George F. Mills, *Treasurer* of the Massachusetts Agricultural Experiment Station of the Massachusetts Agricultural College,

For the Year ending June 30, 1906.

The United States Appropriations, 1906–07.

	Hatch Fund.	Adams Fund.
Dr.		
To receipts from the Treasurer of the United States as per appropriations for fiscal year ended June 30, 1907, under acts of Congress approved March 2, 1887 (Hatch fund), and March 16, 1906 (Adams fund), . . .	$15,000 00	$7,000 00
Cr.		
By salaries, ...	4,568 74	4,731 74
labor, ...	4,202 04	899 32
publications, ...	1,858 60	–
postage and stationery, ...	591 39	–
freight and express, ...	329 50	31 77
heat, light, water and power, . . .	239 16	–
chemical supplies, ...	122 85	152 99
seeds, plants and sundry supplies, . .	542 31	163 02
fertilizers, ...	107 85	96 48
feeding stuffs, ...	495 80	176 55
library, ...	134 82	141 94
tools, implements and machinery, . .	259 80	8 70
furniture and fixtures, ...	371 55	–
scientific apparatus, ...	210 04	439 92
live stock, ...	36 50	–
travelling expenses, ...	648 73	80 57
contingent expenses, ...	28 00	2 00
buildings and land, ...	252 32	75 00
balance, ...	–	–
Total, ...	$15,000 00	$7,000 00

State Appropriation, 1906–07.

Cash received from State Treasurer,	$16,500 00	
from fertilizer fees,	4,745 00	
from farm products,	1,267 21	
from miscellaneous sources,	6,800 42	
		$29,312 63
Cash paid for salaries,	$12,619 97	
for labor,	2,925 76	
for publications,	840 00	
for postage and stationery,	537 29	
for freight and express,	174 13	
for heat, light, water and power,	474 02	
for chemical supplies,	576 47	
for seeds, plants and sundry supplies,	338 48	
for fertilizers,	71 07	
for feeding stuffs,	454 90	
for library,	108 61	
for tools, implements and machinery,	286 84	
for furniture and fixtures,	848 17	
for scientific apparatus,	369 78	
for live stock,	129 05	
for travelling expenses,	1,479 51	
for contingent expenses,	57 50	
for buildings and repairs,	1,122 69	
Balance,	5,898 39	
		$29,312 63

DEPARTMENT OF AGRICULTURE.

WM. P. BROOKS, AGRICULTURIST; E. S. FULTON, E. F. GASKILL, ASSISTANTS.

The work in the department of agriculture during the past year has covered the usual field of experiment, and has been devoted chiefly to an effort to throw light upon some of the many problems connected with the use of manures and fertilizers. The number of field plots used in this work has been 318; the number of closed plots, 153; and the number of pots in vegetation experiments, 330. In the majority of our experiments, repetition from year to year, extending over a considerable period, is desirable in order that accidental variations may be as far as possible eliminated, and in order to bring out the variation in results connected with the varying character of our seasons. A detailed account of the results will be presented for only a small proportion of the experiments in progress.

No inconsiderable share of the time of the agriculturist is occupied in answering the many questions which annually come to the station on all matters pertaining to the practice of agriculture. The number of such inquiries answered during the past year has been 824. Experience indicates that inquiries of the same general character are likely to be sent in many times during the year, and we are therefore adopting in this department, in so far as circumstances warrant, the plan of sending circulars, with such comments as the statement of individual conditions seems to require, which has been referred to in the report of the director.

The more important results of the experiments reported in detail may be briefly stated as follows: —

I. — Experiment to determine the relative value as sources of nitrogen of barnyard manure, nitrate of soda, sulfate of ammonia and dried blood. This experiment was begun in 1890. The crop of this year was clover, sown in the standing corn in August of last year. On the basis of total yield (grass as well as clover included), the materials under comparison rank in the following order: nitrate of soda, dried blood, barnyard manure, sulfate of ammonia. The no-nitrogen plots gave a larger total crop than the sulfate of ammonia, and the clover in these plots was better than on any of the others. On the basis of increase in crop as compared with the product of the no-nitrogen plots, taking into account all the crops grown since the experiment began, the materials on a percentage basis rank as follows: nitrate of soda, 100; barnyard manure, 85.92; dried blood, 70.21; sulfate of ammonia, 45.36.

II. — Experiment to determine the relative value of muriate and high grade sulfate of potash. The crops on the basis of which comparison this year is possible were cabbages, rhubarb, raspberries, blackberries, asparagus, corn and squashes. The sulfate of potash gives the larger crops of raspberries and blackberries. For the other crops the muriate gives the larger crops; but the difference is unimportant except in the case of the asparagus, which is much better on the muriate than on the sulfate.

III. — Experiment to determine the relative value of different potash salts for field crops. The salts under comparison were kainit, high-grade sulfate, low-grade sulfate, muriate, nitrate, carbonate and silicate. The crop was potatoes. The salts, on the average of five trials for each, rank in the following order, as measured by the product of merchantable tubers: low-grade sulfate, muriate, nitrate, high-grade sulfate, silicate, carbonate, kainit. There was considerable scab, — a much greater amount on the carbonate than on the other potash salts.

IV. — Experiment to show the relative value for corn of special corn fertilizers, as compared with a mixture richer in potash. The special corn fertilizer gave a larger yield of sound corn. The fertilizer richer in potash excelled in the product of soft corn and stover. With an earlier spring and a hotter season, the proportion of sound corn produced on the fertilizer richer in potash would undoubtedly have been increased.

V. — Experiment to determine the relative value for production of corn of manure alone, as compared with a smaller application of manure and a moderate amount of sulfate of potash. The larger application of manure alone gave a slightly higher yield of sound corn. The combination of manure and potash gave the higher yields of soft corn and stover. There was not much money difference in the value of the crops produced under the two systems, while the cost of the smaller application of manure and potash was at the rate of about $6 per acre less than the cost of the larger application of manure alone.

VI. — Experiment to determine the relative value, as measured by crop production, of a considerable number of phosphates used in quantities to furnish equal phosphoric acid to each plot. The phosphates under comparison were: fine ground, — apatite, South Carolina rock and Tennessee rock phosphates; Florida soft phosphate, basic slag meal, dissolved bone black, raw bone meal, dissolved bone meal, steamed bone meal and acid phosphate. The crop of the past season was mixed hay. The yields on the different phosphates varied relatively little. Even the plots which have received no phosphates during the eleven years the experiment has continued gave a yield at the first crop at the average rate of about 4 tons to the acre, while the highest yield obtained on any of the phosphates at first cutting was only 9,240 pounds.

VII. — Soil tests. The past season was the nineteenth during which the south soil test reported upon has continued. The results show the surpassing importance for the production of satisfactory corn crops of a liberal supply of potash.

VIII. — Experiment in the application of manures and fertilizers for grass. The materials used are: first, barnyard manure; second, wood ashes; and third, a combination of fine-ground bone and potash. The average yield of hay during the past season was at the rate of 5,005 pounds. The average for the fifteen years during which the experiment has been continued has been 6,296 pounds.

IX. —Winter versus spring application of manure on a slope. The crop of the past year was mixed grass and clover. The experiment was a test simply of the residual fertility from previous applications, as no manure was applied this year, as it was feared it would cause serious lodging of the crop. This judgment was justified by the result. The crop was extremely heavy, and considerably lodged in spite of the fact that manure was not applied this year. The differences in yield were small, and did not indicate greater residual fertility where spring application of manure has been the rule than in the other plots.

X. — Experiment in the application of nitrate of soda for rowen. Owing to the deficiency of rainfall in the latter part of July and August, the rowen crop this year was small. The increase in crop resulting from the application of nitrate was not sufficient on the average to repay the cost of application.

XI. — Experiments in feeding hens. These indicate the great value of animal protein and fat and the injurious influence of fibre in the ration.

I. — Manures and Fertilizers furnishing Nitrogen compared. (Field A.)

The materials under comparison in this experiment, all of which are used in such quantities as to furnish equal nitrogen per plot, are barnyard manure, nitrate of soda, sulfate of ammonia and dried blood. The field includes eleven plots, of one-tenth acre each, and, with few and unimportant exceptions, each plot has been manured in the same way since 1890. Each receives equal and liberal amounts of phosphoric acid and potash, the former in the form of dissolved bone black, the latter in the form of muriate, to plots 1, 3, 6, 7, 8 and 9, and in the form of low-grade sulfate to plots 2, 4, 5 and 10. Three plots have had no nitrogen applied to them in any form since 1884. The various materials are used on the other plots in such quantities as to furnish nitrogen at the rate of 45 pounds per acre. Barnyard manure is applied to one plot, nitrate of soda to two, sulfate of ammonia to three and dried blood to two.

From a period very early in the history of this experiment, the plots to which sulfate of ammonia has been applied have shown a tendency to comparative unproductiveness, due apparently to unfavorable chemical or biological conditions. It was thought probable that application of lime would correct these faulty conditions, and 50 pounds of unslaked lime were applied to plot 6 in 1896. The entire field has been twice limed (in 1898 and 1905) since that date, at the rate of about 1 ton to the acre. In spite of these applications, the yield on the sulfate of ammonia plots, as will be noted, is still much below the average of the other plots.

The crops grown in this experiment previous to this year in the order of their succession have been: oats, rye, soy beans, oats, soy beans, oats, soy beans, oats, oats, clover, potatoes, soy beans, potatoes, soy beans, potatoes, oats and peas, and corn.

The crop the past year was alsike clover, considerably mixed, however, with grass, on all plots except those to which no nitrogen has been applied. The clover was sown in the standing corn on Aug. 6, 1906. When the corn was harvested in the fall of 1906, it was very apparent that the clover was relatively weak and unhealthy on all plots to which nitrogen has been applied during the progress of this experiment. The clover was thicker and more healthy on the three no-nitrogen plots than on any of the others. It was poorest on the sulfate of ammonia plots, and especially poor on the plots where sulfate of ammonia has been used in combination with muriate of potash. The relative condition of the clover on the different plots on the opening of spring was about the same as in the autumn, and as on most of the plots it was too thin for a good crop, 3½ pounds of alsike clover seed were sown per plot on April 3. This seed germinated fairly well, but of course the young plants from this seeding affected the rate of yield in the first crop but little. The rates of yield on the several plots and the sources of nitrogen and potash on each are shown in the following table: —

Yield of Hay and Rowen per Acre (Pounds).

Plots.	Nitrogen Fertilizers used.	Hay.	Rowen.
Plot 0,	Barnyard manure,	3,150	600
Plot 1,	Nitrate of soda (muriate of potash),	4,000	450
Plot 2,	Nitrate of soda (sulfate of potash),	3,900	600
Plot 3,	Dried blood (muriate of potash),	3,050	500
Plot 4,	No nitrogen (sulfate of potash),	3,400	650
Plot 5,	Sulfate of ammonia (sulfate of potash),	2,950	300
Plot 6,	Sulfate of ammonia (muriate of potash),	2,220	500
Plot 7,	No nitrogen (muriate of potash),	3,000	850
Plot 8,	Sulfate of ammonia (muriate of potash),	2,600	400
Plot 9,	No nitrogen (muriate of potash),	2,600	650
Plot 10,	Dried blood (sulfate of potash),	3,850	1,190

The fact that where the clover was relatively thin grasses came in to a considerable extent serves to obscure the effect of the different materials supplying nitrogen on the clover in the first crop. The second or rowen crop was very small on all plots. The principal reasons for this were two: (1) the first crop was cut late on account of bad weather; (2) there was but little rain during the latter part of the summer. The yield of rowen on the no-nitrogen plots, however, stands relatively much higher as compared with the yield on the other plots than was the case with the first crop. This difference was due to the fact that there was relatively little grass mixed with the clover in the rowen crop.

The average yields of this year on the several fertilizers are shown in the following table: —

Fertilizers used.	Pounds per Acre.	
	Hay.	Rowen.
Average of no-nitrogen plots (4, 7, 9),	3,000	717
Average of the nitrate of soda plots (1, 2),	3,950	525
Average of the dried blood plots (3, 10),	3,450	845
Average of the sulfate of ammonia plots (5, 6, 8),	2,590	400

As a result of all the experiments previous to this year, the materials furnishing nitrogen have produced crops in the following relative amounts: —

Relative Crop Averages.	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	96.63
Sulfate of ammonia,	91.08
Dried blood,	89.14
No nitrogen,	70.24

Similar averages for this year are as follows: —

	Per Cent.		
	Hay.	Rowen.	Hay and Rowen.
Nitrate of soda,	100.00	100.00	100.00
Barnyard manure,	79.75	114.29	83.71
Sulfate of ammonia,	65.57	76.19	66.81
Dried blood,	87.37	160.95	95.98
No nitrogen,	76.20	136.57	83.11

Combining the results of this year with those for previous years, on the basis of total yield per plot, the relative standing is : —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	95.91
Dried blood,	91.35
Sulfate of ammonia,	84.13
No nitrogen,	70.96

Averaging our results on the basis of increase in crop as compared with the no-nitrogen plots, the relative standing for the entire period of the experiment, 1890–1907, inclusive, is as follows : —

Relative Increases in Yields (Averages for the Eighteen Years).

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	85.92
Dried blood,	70.21
Sulfate of ammonia,	45.36

It will be noticed that, in spite of the fact that the mixture of grass with the clover, as has been pointed out, tends to obscure the effects of the fertilizer treatment on the latter, the combined yield of hay and rowen on the no-nitrogen plots this year is much greater than on the sulfate of ammonia, and practically the same as on barnyard manure. The yield of clover without doubt was actually greater on the no-nitrogen plots than it was on either the dried blood or the nitrate of soda. The fact has been for some time known that clovers, on account of their ability to draw nitrogen from the air under suitable conditions, are able to make relatively vigorous growth on soils to which no nitrogen is applied, provided these receive generous applications of such elements of plant food as lime, phosphoric acid and potash. Just why, however, the clover should do so much better, as was the case, on the no-nitrogen plots than on the other plots in this field is not at present apparent. It must be remembered that these other plots have received equal applications of lime, phosphoric acid and potash. It has been suggested that the failure of the clover to do well on these plots must be due to residual nitrogen, which during the progress of the experiment has gradually accumulated. Calculation, however, shows that the crops harvested from these plots during the years that the experiment has continued must have removed from the soil larger quantities of nitrogen than had been applied.

The fact that the soil has been so heavily limed twice within recent years seems to preclude the conclusion that the relative failure of the clover is due to an acid condition of the soil; and, indeed, careful chemical analyses of samples taken last spring show that the soil of these plots does not, as a rule, contain appreciable quantities of free acid. We are unable, then, at present to account for the results obtained; but careful chemical and biological investigations will be carried out, with a view to throwing light upon this most important question.

II. — The Relative Value of Muriate and High-grade Sulfate of Potash. (Field B.)

In this experiment, which was begun in 1892, muriate of potash is compared with high-grade sulfate, on a basis of such applications as will furnish equal actual potash per acre in connection with an annual application of fine-ground bone at the rate of 600 pounds per acre. Potash has been applied in different years in varying quantities. At first the applications were exceptionally heavy, — 350 to 400 pounds per acre of these salts were applied. Since 1900 each has been applied at the rate of 250 pounds per acre annually.

The crops during the progress of the experiment have embraced nearly all those common to this latitude. During the past year they have been: cabbages on two plots; asparagus, rhubarb, raspberries and blackberries, all on each of two plots; corn on four; and squashes on two. The rates of yield of the various crops on the different fertilizers are presented in the following table: —

Crops.	Fertilizers used.	Plot.	Yield per Acre (Pounds).		
Cabbages,	Muriate of potash,	11	39,522.70		
	Sulfate of potash,	12	38,461.50		
			Stalks.	Leaves.	
Rhubarb,	Muriate of potash,	13	30,733.90	24,526.00	
	Sulfate of potash,	14	30,685.30	26,168.20	
Raspberries,	Muriate of potash,	13	42.05		
	Sulfate of potash,	14	105.14		
Blackberries,	Muriate of potash,	13	365.38		
	Sulfate of potash,	14	738.76		
Asparagus,	Muriate of potash,	13	4,071.10		
	Sulfate of potash,	14	2,428.00		
			Hard.	Soft.	Stover.
Corn,	Muriate of potash,	15	63.56 bush.	6.05 bush.	7,943.80
	Sulfate of potash,	16	63.02 bush.	5.61 bush.	7,739.00
Corn,	Muriate of potash,	17	64.78 bush.	5.78 bush.	8,052.00
	Sulfate of potash,	18	64.94 bush.	7.10 bush.	7,781.40
Squashes,	Muriate of potash,	19	10,810.70		
	Sulfate of potash,	20	8,378.40		

Cabbages. — The yield of cabbages on the two potash salts this year is substantially equal. The crop on both was good. This result is not in agreement with results which we have usually obtained. As a rule, the sulfate of potash has given us larger crops of cabbages and better headed than muriate. The crop on this salt this year shows a slight inferiority in total yield. This difference is perhaps accounted for by the fact that the latter part of the summer was exceptionally dry. In seasons with less than normal rainfall and on light soils the muriate of potash often shows itself to be superior to the sulfate for crops which under opposite conditions give the best results with the sulfate.

Rhubarb. — With this crop, as with the cabbages, the results are substantially equal, whereas in earlier years the sulfate has given the larger yields. The explanation is perhaps that suggested in discussing the results with cabbages.

Asparagus. — It will be noticed that the yield of asparagus on the muriate of potash is much larger than on the sulfate. This is in accordance with the results which have previously been obtained with this crop. The customary practice of depending largely upon muriate as a source of potash would appear, therefore, to be wise.

Raspberries and Blackberries. — The yield of both these fruits is exceedingly small, as both were seriously winter-killed. This year, however, as in earlier years, the yield on the sulfate of potash is much greater than on the muriate. This difference in yield is undoubtedly mainly a consequence of the fact that the canes produced where sulfate of potash is applied are better ripened and go through the winter better than where muriate is used.

Squashes. — The variety of squashes grown, Delicious, was planted on June 29, having been put in after two failures to get a satisfactory start of carrots on the plots occupied. The date of planting was, of course, far later than is desirable. Autumn frosts, however, held off later than usual, and a moderate crop was secured. The yield on the muriate was considerably greater than on the sulfate.

Corn. — Plots 15, 16, 17 and 18 were occupied by a variety test of sixteen different kinds of corn, forwarded for trial by the Bureau of Plant Industry of the Department of Agriculture. The results for the different varieties have not yet been fully worked up, and the total yields only are presented in detail. On one of the pairs of plots the muriate gives a considerably larger crop of grain ; on the other the crops are substantially even. The muriate gives the larger yield of stover in both cases. The latter result is in accordance with those which we have usually obtained where these potash salts have been compared for corn. Earlier experiments have not shown any considerable difference in the value of the two salts for grain production, and the results of this year, not being in agreement on the two pairs of plots, cannot be regarded as especially significant. They were possibly somewhat affected by the fact that so large a number of varieties was included in the experiment ; although an effort to equalize conditions was made by running the rows of the different varieties across the plots, so that each plot included the same quantity of each of the several kinds.

As of possible interest, it may be here stated that among the different kinds grown in this experiment, which included some of those found in the experiments conducted by the department in various parts of the country to be the most promising, flint and dent varieties both being included, the largest yield was furnished by a variety of dent corn known as Minnesota No. 13 and the next largest by the Rustler White dent, a variety largely grown on the college farm in Amherst for the past two years, and obtained originally from a seedsman in Minnesota. Both of these varieties were fairly well ripened, although the cold, rainy spring and early summer months were highly unfavorable to the corn crop in this locality.

III. — Comparison of Different Potash Salts for Field Crops. (Field G.)

The general plan of this experiment is briefly stated in the nineteenth annual report, from which I quote : —

> This experiment is designed to show the ultimate effect upon the soil, as well as the current effect upon the crops, of continuous use of different potash salts. We have under comparison kainit, high-grade sulfate, low-grade sulfate, muriate, nitrate, carbonate and silicate. The field includes forty plots, in five series of eight plots each. Each series includes a no-potash plot, as well as the seven potash salts which have been named. The experiment is therefore carried out each year in quintuplicate. The area of each plot is one-fortieth of an acre. The potash salts under comparison are used in quantities which will supply annually actual potash at the rate of 165 pounds per acre to each of the plots. All plots are equally manured, and liberally, with materials furnishing nitrogen and phosphoric acid.

The experiment began in 1898, and the crops in the several years have been as follows : —

1898. Medium Green soy beans.
1899. Potatoes.
1900. Plots 1–8, cabbage; 9–24, Medium Green soy beans; 25–40, cow peas.
1901. 1–8, wheat; 9–40, corn.
1902. Clover.
1903. Clover.
1904. 1–16, cabbage; 17–40, corn.
1905. Soy beans.
1906. Potatoes.
1907. Potatoes.

As the results of last year indicated an important relation between the supply of potash in available form and the prevalence of blight, it was decided to plant the field to potatoes again in 1907, although it was recognized that this plan involved considerable risk that the crop would be seriously affected by scab, since, in spite of the fact that the seed planted in this field has always been thoroughly treated for destruction of the scab fungus, it had been noticed that the crop in a portion of the plots was somewhat affected by this disease. The amount of scab showing itself this year was unexpectedly serious, and this fact clearly indicates the soundness of the conclusion that potatoes should not as a rule be grown twice in succession upon the same field.

The variety of potatoes grown this year was Green Mountain. The seed was treated with formalin solution in the usual manner. On account of excessive rains throughout the early spring, planting was deferred until later than usual, — May 23. The crop was thoroughly cared for throughout the season, and sprayed twice with different combinations of fungicides and insecticides.[1] The yields per plot and the rates of yield per acre are shown in the following table : —

Plots.	Potash Salt.	Pounds per Plot.			Bushels per Acre.		
		Large.	Small.	Rotten.	Large.	Small.	Rotten.
Plot 1, .	No potash, . . .	268.00	34.75	–	178.67	23.17	–
Plot 2, .	Kainit, ...	354.50	31.00	–	236.33	20.67	–
Plot 3, .	High-grade sulfate, .	367.00	33.50	–	244.67	22.33	–
Plot 4, .	Low-grade sulfate, .	369.50	23.00	–	246.33	15.33	–
Plot 5, .	Muriate, . . .	353.25	47.50	1.00	235.50	31.67	.67
Plot 6, .	Nitrate, ...	372.00	19.00	.75	248.00	12.67	.50
Plot 7, .	Carbonate, . . .	328.25	39.25	–	218.83	26.17	–
Plot 8, .	Silicate, ...	345.50	36.00	9.00	230.33	24.00	6.00
Plot 9, .	No potash, . . .	333.75	36.25	13.50	222.50	24.17	9.00
Plot 10, .	Kainit, ...	396.50	19.50	–	264.33	13.00	–
Plot 11, .	High-grade sulfate, .	386.50	27.50	.50	257.67	18.33	.33
Plot 12, .	Low-grade sulfate, .	400.00	27.75	.75	266.67	18.50	.50
Plot 13, .	Muriate, . . .	401.50	27.00	–	267.67	18.00	–

[1] For account of spraying experiments and results, see report of the botanist and vegetable pathologist, page 128.

Plots.	Potash Salt.	Pounds per Plot.			Bushels per Acre.		
		Large.	Small.	Rotten.	Large.	Small.	Rotten.
Plot 14, .	Nitrate, ...	391.00	25.25	–	260.67	16.83	–
Plot 15, .	Carbonate, . . .	391.25	34.00	–	260.83	22.67	–
Plot 16, .	Silicate, ...	404.00	27.50	1.00	269.33	18.33	.67
Plot 17, .	No potash, . . .	301.25	33.00	1.50	200.83	22.00	1.00
Plot 18, .	Kainit, ...	339.50	13.00	.50	226.33	8.67	.33
Plot 19, .	High-grade sulfate, .	328.00	17.50	45.00	218.67	11.67	30.00
Plot 20, .	Low-grade sulfate, .	383.50	17.25	37.00	255.67	11.50	24.67
Plot 21, .	Muriate, . . .	333.00	15.25	56.00	222.00	10.17	37.33
Plot 22, .	Nitrate, ...	330.00	20.50	54.50	220.00	13.67	36.33
Plot 23, .	Carbonate, . . .	314.00	23.50	59.00	209.33	15.67	39.33
Plot 24, .	Silicate, ...	330.00	16.00	72.00	220.00	10.67	48.00
Plot 25, .	No potash, . . .	166.00	27.75	46.00	110.67	18.50	30.67
Plot 26, .	Kainit, ...	279.00	10.25	30.00	186.00	6.83	20.00
Plot 27, .	High-grade sulfate, .	370.50	11.50	29.00	247.00	7.67	19.33
Plot 28, .	Low-grade sulfate, .	366.75	23.00	6.00	244.50	15.33	4.00
Plot 29, .	Muriate, . . .	359.00	23.75	4.50	239.33	15.83	3.00
Plot 30, .	Nitrate, ...	336.00	24.25	2.00	224.00	16.17	1.33
Plot 31, .	Carbonate, . . .	340.00	37.00	–	226.67	24.67	–
Plot 32, .	Silicate, ...	372.50	28.50	–	248.33	19.00	–
Plot 33, .	No potash, . . .	198.00	25.00	–	132.00	16.67	–
Plot 34, .	Kainit, ...	284.00	14.50	–	189.33	9.67	–
Plot 35, .	High-grade sulfate, .	323.50	26.00	–	215.67	17.33	–
Plot 36, .	Low-grade sulfate, .	324.50	21.25	–	216.33	14.17	–
Plot 37, .	Muriate, . . .	297.50	33.00	–	198.33	22.00	–
Plot 38, .	Nitrate, ...	304.00	28.50	–	202.67	19.00	–
Plot 39, .	Carbonate, . . .	300.00	30.25	–	200.00	20.17	–
Plot 40,[1] .	Silicate, ...	226.00	33.25	–	150.66	22.17	–

The average yields of sound tubers under the varying fertilizer treatments were as follows: —

[1] Owing to a shortage in the available supply of silicate of potash, and the impossibility of procuring more, the quantity applied to this plot was only about one-sixth of the regular amount.

Potatoes.—Average Yields per Acre (Bushels).

Potash Salt.	Large.	Small.
No potash (plots 1, 9, 17, 25, 33), ...	168.93	20.90
Kainit (plots 2, 10, 18, 26, 34), ...	220.47	11.77
High-grade sulfate (plots 3, 11, 19, 27, 35), ...	234.73	15.47
Low-grade sulfate (plots 4, 12, 20, 28, 36), ...	245.90	14.97
Muriate of potash (plots 5, 13, 21, 29, 37), ...	236.57	19.53
Nitrate (plots 6, 14, 22, 30, 38), ...	235.07	15.67
Carbonate (plots 7, 15, 23, 31, 39), ...	223.13	21.87
Silicate (plots 8, 16, 24, 32, 40), ...	223.73	18.83

The no-potash plots this last year gave a yield much inferior to that produced on the plots receiving potash. The highest average yield was produced on the low-grade sulfate of potash: the lowest on the kainit. The differences between the different potash salts, exclusive of the kainit, are, however, relatively small. The full table showing the rates of yield per plot shows that there was considerable rot on about one-half of the plots. Dr. Stone failed to discover *Phytophthera infestans* on the foliage. The rot did not set in until the heavy rains of autumn. The variation in the proportion of decayed tubers in the different plots appears to be due to a difference in moisture conditions. There seems to be no well-defined influence on the proportion of decayed tubers which can be attributed to the potash salt employed. This year, as last, the foliage of the vines on the no-potash plots died much earlier than on any of the plots receiving potash. This premature death of the foliage may, however, have been due simply to lack of vigor consequent upon deficiency of potash in the soil, as Dr. Stone failed to find the characteristic fungi causing either the early or the late blight. It is probable, however, that in seasons with climatic conditions more favorable to the blight fungi they would attack the relatively weak foliage of plants growing where potash is deficient more seriously than they would the more vigorous foliage of better-nourished plants.

IV. — North Corn Acre. — Special Fertilizer *v.* Fertilizer Richer in Potash.

This experiment, which was begun in 1891, is designed to test the question whether the special corn fertilizers as offered in our markets are of such composition as seems to be best suited for the production of corn and mixed hay in rotation. The experiment occupies an acre of ground, and is divided into four equal plots, numbered from 1 to 4. Plots 3 and 4 were sown to millet during the first two years of the experiment, but with this exception their treatment has been the same as that of plots 1 and 2, 3 being a duplicate of 1 both as regards fertilizer application and crops produced, and 4 a duplicate of 2. The field has been in mixed grass and clover during three two-year periods, 1897–98, 1901–02 and 1905–06. With these exceptions, and with the further exception referring to millet noted above, corn has been the crop. Whenever the field has been put into grass and clover, it has been seeded in the standing corn of the previous year. Plots 1 and 3 have yearly received an application of fertilizers (a home mixture), furnishing nitrogen, phosphoric acid and potash at the rate per acre which would be supplied by 1,800 pounds of fertilizer having the composition of the average of the special corn fertilizers analyzed at this station. We have made but one change since 1899, as this average changes but little from year to year. The average composition of such fertilizers at that time was as follows: —

	Per Cent.
Nitrogen,	2.37
Phosphoric acid,	10.00
Potash,	4.30

The fertilizer used on plots 2 and 4 has been a home mixture richer in potash and much poorer in phosphoric acid than the mixture representing the average corn fertilizers offered in the market. The difference in the application of the fertilizer elements is made clear in the following table: —

Fertilizer Elements applied annually.

Plots.	Rates per Acre (Pounds).		
	N	P_2O_5	K_2O
Plots 1 and 3,	42.6	180	77.4
Plots 2 and 4,	47.0	50[1]	125.0

The materials applied annually to the several plots are as follows: —

Fertilizers used.	Plots 1 and 3 (Pounds Each).	Plots 2 and 4[2] (Pounds Each).
Nitrate of soda,	30.0	50.0
Dried blood,	30.0	–
Dry ground fish,	37.5	50.0
Acid phosphate,	273.0	50.0[1]
Muriate of potash,	37.5	62.5

This field was limed in 1900 at the rate of 1 ton to the acre, and again this year at the same rate.

For the past two years the land has been in mixed grass and clover. The sod was plowed in May, and the corn, Rustler White dent, was planted on May 25. The rates of yield on the several plots and the averages for the two systems of manuring are shown in the following tables: —

Yields per Acre.

Plots.	Sound Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).
Plot 1 (lesser potash),	59.75	4.24	6,400
Plot 2 (richer in potash),	56.00	7.10	7,060
Plot 3 (lesser potash),	57.75	5.75	6,760
Plot 4 (richer in potash),	52.00	8.25	6,720

[1] By mistake plots 2 and 4 received the same application of acid phosphate in 1906 as plots 1 and 3.

[2] Plot 4 this year received in addition 100 pounds of basic slag meal.

Average Yields per Acre.

Plots.	Sound Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).
Plots 1 and 3 (lesser potash),	58.75	5.00	6,580
Plots 2 and 4 (richer in potash),	54.00	7.68	6,890

It will be noticed that the combination of fertilizers representing the special corn fertilizer gives an average yield of sound corn at the rate of about 4¾ bushels per acre more than plots 2 and 4. The yield of soft corn and of stover is, however, larger on plots 2 and 4. We have here an illustration of the well-known effect of a liberal supply of soluble phosphoric acid in hastening maturity, — an effect which was especially important during the past season, on account of the cold and rainy spring and the low average summer temperature. The greater weight of stover (field cured) on plots 2 and 4 may be in part a consequence of the fact that the crop was not so fully matured, although it has been repeatedly noted in our experiments that a liberal supply of potash promotes a heavy yield of forage. The addition of the basic slag meal to plot 4 has produced no apparent benefit during the past season.

V. — South Corn Acre. — Manure Alone *v.* Manure and Potash.

The objects in view in this experiment and the general plan are stated in the following quotation from my last annual report: —

The object in view in this experiment is to compare the crop-producing capacity of manure alone applied in fairly liberal amounts with a combination of a lesser amount of manure and a moderate quantity of a potash salt. An acre of land is used in the experiment. It is divided into four plots, of one-quarter acre each. Two of the plots (1 and 3) have received applications of manure only; the other two plots (2 and 4) have been fertilized by applications of lesser amounts of manure, together with a potash salt.

This experiment was begun in 1891. The crop for the first six years was corn. Corn was raised also in 1899 and 1900, and in 1903 and 1904. The field has been put into mixed grass and clover three times, being seeded in the summer preceding the first year of cutting in the corn crop.

Each time that the land has been seeded it has been cut twice annually for two years. The sod has then been broken in the fall for the corn crop of the following year. The years when the field has been in mowing are 1898 and 1899, 1901 and 1902, and 1905 and 1906.

Manure has been applied to plots 1 and 3 every year, at the rate of 6 cords per acre, with the following exceptions. No manure was applied in 1897, 1902 and 1905, and in 1898 the amount applied was at the rate of 4 cords per acre. The reason for the omission of manure in the years mentioned and for the smaller amount in 1898 was that experience indicated that its application would cause the grass and clover to lodge badly.

Manure has been applied to plots 2 and 4 as follows: in 1891 and 1892, at the rate of 3 cords per acre; in 1898, at the rate of 2 cords per acre; while in 1897, 1902 and 1905 no manure was applied. In all other years the application has been at the rate of 4 cords per acre. Potash has been applied to plots 2 and 4 at the rate of 160 pounds per acre of high-grade sulfate annually, except in the years when no manure was applied. In these years the potash also was withheld.

The entire field was limed in 1900 at the rate of 1 ton per acre. The manure used has been from well-fed milch cows, and has usually weighed about 3 tons per cord. Both manure and fertilizer were applied broadcast after plowing, and harrowed in.

The following tables show the rates of yield on the several plots and the averages under the two systems of manuring: —

Yields per Acre, 1907.

Plots.	Sound Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).
Plot 1 (manure alone),	65.50	6.00	7,080
Plot 2 (manure and potash),	60.40	7.78	7,508
Plot 3 (manure alone),	64.25	6.00	7,380
Plot 4 (manure and potash),	62.25	8.25	7,120

Average Yields per Acre.

Plots.	Sound Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).
Plots 1 and 3 (manure alone),	64.88	6.00	7,230
Plots 2 and 4 (manure and potash),	61.33	8.02	7,314

It will be noticed that the yield of sound corn is somewhat larger on the heavier application of manure alone than on the combination of a lesser quantity of manure and the potash. On the other hand, the average yield of soft corn and of stover is greater on the combination of manure and potash. This result is in some respects analogous to that obtained with fertilizers on the north corn acre. In a more favorable season, the combination of manure and potash is likely to make a better relative showing. In estimating the significance of the results actually obtained, however, it should be kept in mind that, assuming the farmyard manure to cost $5 per cord applied to the field, the annual difference in cost of materials applied under the two systems of manuring has amounted to about $6 per acre, the application of the lesser amount of manure and the potash costing about that amount less than the larger application of manure.

VI. — Comparison of Phosphates on the Basis of Equal Application of Phosphoric Acid.

This experiment, comparing different phosphates, has been in progress eleven years. The phosphates under comparison are as follows: apatite (fine ground[1]), South Carolina rock phosphate (fine ground), Florida soft phosphate, basic slag meal, Tennessee rock phosphate (fine ground), dissolved bone black, raw bone meal, dissolved bone meal, steamed bone meal and acid phosphate. Each is applied in such quantities as to furnish phosphoric acid at the rate of 96 pounds per acre. Three plots have received no phosphoric acid during the entire period of the experiment. All plots have annually received an application of materials furnishing nitrogen and potash and in equal amounts, nitrogen being furnished at the rate of 52 pounds and potash at the rate of 152 pounds per acre. In the case of a few crops requiring especially high manuring (onions and cabbages), a supplementary application of quick-acting nitrogen fertilizers has been made to all plots alike. The crops grown in this field in the order of succession have been as follows: corn, cabbages, corn, — in 1900 two crops, — oats and Hungarian grass (both for hay), onions, onions, cabbages, and mixed grass and clover for two years. The plots were seeded to mixed grass and clover in the spring of 1905; the present is therefore the third year that they have been in grass. The yields and the gain or

[1] Not used either in 1906 or 1907, as it is not offered by dealers.

loss as compared with the no-nitrogen plots are shown in the following table : —

Plots.	Fertilizers used.	Yield per Plot (Pounds).		Yield per Acre (Pounds).		Gain or Loss (Pounds).	
		Hay.	Rowen.	Hay.	Rowen.	Hay.	Rowen.
Plot 1,	No phosphate, ...	1,050	50	8,400	400	-	-
Plot 2,	Apatite, ...	1,100	63	8,800	504	867	+71
Plot 3,	South Carolina rock phosphate,	1,060	62	8,480	496	547	+163
Plot 4,	Florida soft phosphate, . .	1,060	50	8,480	400	547	+67
Plot 5,	Phosphatic slag, . . .	1,045	52	8,360	416	427	+83
Plot 6,	Tennessee phosphate, . .	1,005	41	8,040	328	107	—5
Plot 7,	No phosphate, ...	1,020	30	8,160	240	-	-
Plot 8,	Dissolved bone black, . .	1,150	61	9,200	488	1,267	155
Plot 9,	Raw bone, ...	1,155	63	9,240	504	1,340	171
Plot 10,	Dissolved bone meal, . .	1,145	63	9,160	504	1,227	171
Plot 11,	Steamed bone meal, . . .	1,040	70	8,320	560	387	227
Plot 12,	Acid phosphate, . . .	1,005	75	8,040	600	107	267
Plot 13,	No phosphate, ...	905	45	7,240	360	-	-

It will be noted that the first crop was exceptionally heavy. The large yield was without doubt due in considerable measure to the weather conditions, which were exceptionally favorable for hay in this locality. Such yields, however, must have been impossible but for the liberal fertilization which the field has received.

It will be noticed that even the no-phosphate plots have given a yield averaging nearly 4 tons per acre at the first cutting. The highest yields were afforded by the dissolved bone black, raw bone and dissolved bone meal, between which there was relatively little difference ; but the fact that the yield on the plot receiving apatite was but little inferior to the yield on these best plots, while with such crops as cabbages in past years it has been hardly one-half as great, taken in connection with the relatively large yield of the no-phosphate plots, sufficiently emphasizes the relative unimportance of supplying phosphoric acid in soluble form for such a crop as mixed grass and clover. The soluble phosphates in this experiment when cabbages were the crop gave yields about two to five times as great as the no-phosphate or the insoluble phosphate plots, while this year the differences are comparatively insignificant. The yield of rowen this year was exceptionally small, and for the same reasons as those which have been mentioned in discussing the results on Field A, viz.: late cutting of the first crop, and protracted drought during the latter part of the summer.

VII. — Soil Tests.

Soil test work has been continued upon the two acres which have been used so long in work of this description. The plan is the co-operative method adopted in convention in Washington in 1889. The crops of this year have been, on one acre, corn; on the other, mixed grass and clover. The latter was sown this spring, and the crop, which was considerably mixed with weeds, was not weighed separately for the different plots. No detailed report will be made, therefore, for this acre. In this soil test work the kinds of fertilizers and the rates of application per acre are as follows: —

Nitrate of soda, 160 pounds, furnishing nitrogen.
Dissolved bone black, 320 pounds, furnishing phosphoric acid.
Muriate of potash, 160 pounds, furnishing potash.
Land plaster, 800 pounds.
Lime, 800 pounds.
Manure, 5 cords.

Soil Test with Corn (South Acre). — This acre has been used in soil tests for nineteen years, beginning in 1889. The field was limed, each time at the rate of 1 ton per acre, in 1899 and 1904. Early in the spring of the present season it received another application of lime, at the rate of 1,000 pounds per acre of R. R. agricultural lime, manufactured by the Rockland-Rockport Lime Company. This was spread after plowing, as in previous years, and harrowed in. The crops for the successive years have been as follows: corn, corn, oats, grass and clover, grass and clover, corn (followed by mustard as a catch crop), rye, soy beans, white mustard, corn, corn, grass and clover, grass and clover, corn, corn, corn, grass and clover, grass and clover. The crop for the present season was corn, which is, therefore, the ninth corn crop grown in the field since the experiment began in 1889. Three times during this period the field has been put into mixed grass and clover, each time for two years. The third grass and clover period ended last year. The sod, however, was not turned until last spring. The soil was well prepared, but, owing to the cold and rainy spring, the crop, Rustler White dent, was not planted until June 1. The character of the past season, as has been pointed out in another section of this report, was rather unfavorable for corn. The following table shows the fertilizers used on the several plots, the rates of yield and the gain or loss per acre compared with the nothing plots: —

Corn. — South Acre Soil Test, 1907.

Plots.	Fertilizers used.	Yield per Acre.		Gain or Loss per Acre, compared with Nothing Plots.	
		Corn (Bushels).	Stover (Pounds).	Corn (Bushels).	Stover (Pounds).
Plot 1, .	Nitrate of soda, ...	1.00	720	—1.00	—280
Plot 2, .	Dissolved bone black, . . .	.81	700	—1.19	—300
Plot 3, .	Nothing, ...	2.00	1,000	-	-
Plot 4, .	Muriate of potash, ...	23.31	6,000	+21.23	+4,967
Plot 5, .	Lime, ...	1.25	900	—.92	—167
Plot 6, .	Nothing, ...	2.25	1,100	-	-
Plot 7, .	Manure, ...	72.50	6,900	+70.25	+5,800
Plot 8, .	Nitrate of soda and dissolved bone black.	10.06	2,500	+6.25	+1,400
Plot 9, .	Nothing, ...	3.81	1,100	-	-
Plot 10, .	Nitrate of soda and muriate of potash.	31.13	5,400	+27.46	+4,400
Plot 11, .	Dissolved bone black and muriate of potash.	30.13	6,500	+26.61	+5,600
Plot 12, .	Nothing, ...	3.38	800	-	-
Plot 13, .	Plaster, ...	7.75	1,200	+4.37	+400
Plot 14, .	Nitrate of soda, dissolved bone black and muriate of potash.	38.31	5,500	+34.93	+4,700

It will be noticed that the yield on the nothing plots is excessively small, amounting on the average to but little more than 2½ bushels of shelled corn per acre and about 1,000 pounds of stover. The use either of nitrate of soda or of dissolved bone black alone gives absolutely no increase; indeed, the crops on these single fertilizer materials were smaller than on the nothing plots. On the other hand, the use of muriate of potash at the rate of 160 pounds per acre (for this, the nineteenth year during which the land has been fertilized only with this material) gives an increase at the rate of rather over 20 bushels of corn and nearly 2½ tons of stover per acre. The tables which follow bring out the effects of the different fertilizer elements when used alone or in different combinations with great clearness: —

	Results of the Addition of Nitrogen to —				
	Nothing.	Phosphoric Acid.	Potash.	Phosphoric Acid and Potash.	Average Results.
Corn (bushels),	−1.00	+7.44	+6.23	+8.32	+5.25
Stover (pounds),	−280.00	+1,700.00	−567.00	−900.00	−11.75

Value of increase,	$3 89[1]
Financial result (loss),	11

	Results of the Addition of Phosphoric Acid to —				
	Nothing.	Nitrogen.	Potash.	Nitrogen and Potash.	Average Results.
Corn (bushels),	−1.19	+7.25	+5.38	+7.47	+4.73
Stover (pounds),	−300.00	+1,680.00	+633.00	+300.00	+578.00

Value of increase,	$5 89
Financial result (gain),	3 01

	Results of the Addition of Potash to —				
	Nothing.	Nitrogen.	Phosphoric Acid.	Nitrogen and Phosphoric Acid.	Average Results.
Corn (bushels),	21.23	28.46	27.80	28.68	26.54
Stover (pounds),	4,967.00	4,680.00	5,900.00	3,300.00	4,712.00

Value of increase,	$38 75
Financial result (gain),	35 15

[1] The financial calculations in these tables were based on the following prices: —

Nitrate of soda,	$50 00 per ton.
Muriate of potash,	45 00 per ton.
Dissolved bone black,	18 00 per ton.
Lime,	6 00 per ton.
Plaster,	10 00 per ton.
Manure,	5 00 per cord.
Corn,	75 per bush.
Stover,	8 00 per ton.

	Results of the Addition to Nothing of —			
	Lime.	Manure.	Plaster.	Complete Fertilizer.
Corn (bushels),	—.92	+70.25	+4.37	34.93
Stover (pounds),	—167.00	+5,800.00	400.00	4,700.00
Value of increment,	-	$75 89	$4 88	$45 00
Value of decrease,	$1 36	-	-	-
Financial result,	3 76 (loss).	50 89 (gain).	88 (gain).	34 52 (gain).

The first of these tables shows that, although nitrate of soda, when used alone, does not increase the crop, it gives a small increase when used in connection with either of the other fertilizer materials alone or with the two together. The nitrate when used in connection with either potash alone or with potash and dissolved bone black has apparently at the same time increased the yield of grain and decreased that of stover. No explanation of this result can be offered. We have, however, figured results on the weights of field-cured stover, and it is possible that variation in moisture content obscures real effects, although this is not believed to be the case, as similar results have been obtained in other years.

The second of these tables shows that, while phosphoric acid used alone gives no increase, it gives a moderate increase both in grain and in stover when used with either of the other fertilizer materials or with both. It will be noticed that on the average the value of the increase in crop due to the use of the phosphate exceeds the cost of that fertilizer.

The third table shows the results obtained by the use of potash. The fact is at once evident that this is the dominant element for the corn crop in this soil. It will be noted that even when used by itself it gives a large increase. It seems surprising that the increase produced when the potash is used in connection with both the other fertilizer elements does not compare more favorably with the increase when it is used alone. We have, it is true, a somewhat larger increase in grain. On the other hand, the increase in stover is not as great as that produced when the potash is used alone. The value of the increase produced by the use of potash greatly exceeds the cost of this fertilizer element.

The last of the four tables under consideration shows the results, as compared with the nothing plots, of the use respectively of the lime, the manure, the plaster and the complete fertilizer. The lime used alone proves absolutely valueless. The manure gives a heavy crop, and its use is highly profitable. Plaster produces a small increase. Complete fertilizer produces a fair crop, and is moderately profitable.

Attention is here called to the fact, previously noted in referring to this field, that the object in view is not to demonstrate the possibility of producing large crops, but to bring out the specific effects of long-continued use of the different fertilizer elements and fertilizer combinations. A more profitable crop could undoubtedly be produced on fertilizers by making a more liberal application. The possibility of doing this is sufficiently demonstrated by the results obtained in raising corn in alternation with mixed mowings on fertilizers alone on the north corn acre,[1] where highly profitable crops have been yearly produced. This soil test work, taken in connection with other experimental work, a part of which is referred to in this report, and in connection with results obtained in various parts of the State, certainly indicates the desirability of a more general and larger use of fertilizers rich in potash in the production of the corn crop.

VIII. — Experiment in Manuring Grass Land.

The plan of this experiment will be understood from the following outline, quoted from my sixteenth annual report: —

In this experiment, which has continued since 1893, the purpose is to test a system of using manures in rotation for the production of grass. The area used in the experiment is about 9 acres. It is divided into three approximately equal plots. The plan is to apply to each plot one year barnyard manure, the next year wood ashes, and the third year, fine-ground bone and muriate of potash. As we have three plots, the system of manuring has been so arranged that every year we have a plot illustrating the results of each of the applications under trial. The rates at which the several manures are employed are as follows: barnyard manure, 8 tons; wood ashes, 1 ton; ground bone, 600 pounds; and muriate of potash, 200 pounds, per acre. The manure is always applied in the fall; ashes and the bone and potash in early spring.

[1] See page 43.

The past season in this part of Massachusetts was in general favorable to a large yield of hay at the first cutting, but the rowen crop was in most fields much smaller than usual, on account of the deficiency of rainfall during the latter part of July and August. It will be noted, however, that the yields in this field during the past season were considerably under the general average for the entire period of the experiment. The results for each of the systems of manuring is shown in the table: —

Fertilizers used.	Yield per Acre.		
	Hay (Pounds).	Rowen (Pounds).	Total (Pounds).
Barnyard manure,	3,517	1,205	4,722
Bone and potash,	3,903	1,728	5,631
Wood ashes,	3,083	1,579	4,662

The average for the entire area this year was 5,005 pounds. The average from 1893 to 1906, inclusive, was 6,389 pounds of well-dried hay per acre annually. The average to date, including the crop of the past season, is 6,296 pounds. A comparison of the average yield throughout the entire period for each of the several systems of manuring will be of interest. These averages are as follows: —

	Pounds per Acre.
When top-dressed with manure,	6,525
When top-dressed with wood ashes,	5,965
When top-dressed with bone and muriate,	6,284

In each of plots 1 and 2 two different mixtures of grass seeds are under comparison on equal areas. One of the mixtures in each plot is the usual farmer's mixture of timothy, redtop and clovers. The other mixture contains a considerable variety of seeds, but tall and meadow fescues are the predominating species. These plots were seeded in 1902. During the first few years the timothy mixture gave the larger yields. During the past season the fescue mixture has given the larger total yields on both plots. The differences, however, are not large.

IX. — Experiment in the Application of Manure.

Full details with reference to the plan followed in this experiment will be found in the nineteenth annual report. Briefly stated, the object is to compare results obtained through spreading manure as it is removed from stables during the winter with the practice of storing in a heap in the open air until spring and then spreading. The field which is used in this experiment slopes quite rapidly toward the west. The experiment was begun in 1899; the past season, therefore, is the ninth during which the experiment has continued. The crop this year was mixed grass and clover, sown in the standing corn of the previous year. No manure was applied either in winter or spring this year, as it was apparent that the land, which has been manured annually at the rate of 6 cords to the acre for the past eight years, would produce as rank a growth as was desirable. The rates of yield per acre and the relative standing of the several plots are shown in the following table: —

Grass and Clover. — Actual Yields (Pounds per Acre).

Plots.	North Half, Winter Application.		South Half, Spring Application.	
	Hay.	Rowen.	Hay.	Rowen.
Plot 1,	6,885	973.3	6,903	1,081.5
Plot 2,	6,885	1,261.7	6,795	1,135.5
Plot 3,	5,948	1,279.7	6,363	1,117.5
Plot 4,	6,633	973.3	6,164	1,027.4
Plot 5,	6,327	558.8	6,020	973.3

Grass and Clover. — Relative Yields (Per Cent.).

Plots.	North Half, Winter Application.		South Half, Spring Application.	
	Hay.	Rowen.	Hay.	Rowen.
Plot 1,	100	100	100.26	111.12[1]
Plot 2,	100	100	98.69	90.32
Plot 3,	100	100	106.98	87.32
Plot 4,	100	100	92.93	105.56
Plot 5,	100	100	95.15	174.18

[1] These yields of rowen less accurately measure the fertility than the first crop, for the grass and clover both were unevenly killed in spots by the lodging of the first crop.

The crops of this year are of course a measure only of the residual fertility from previous manuring. The yield was heavy, but, as will be noticed, it was not uniformly favorable to either system of application, although on the whole the plots to which the manure has been applied during the winter gave the heavier yields. These experiments to date do not support the view that the waste following winter application of manure is sufficiently serious to offset the saving in labor, as compared with the system of double handling which storing in heaps to be spread in the spring involves. Our records indicate that spring application costs at the rate of about $4.80 per acre more than the single handling, where the manure is spread when hauled during the winter.

X. — Nitrate of Soda for Rowen.

This experiment was designed to determine whether the application of nitrate of soda made soon after the first crop is cut will give a profitable increase in rowen. The field, although originally seeded to pure timothy in 1897, now gives crops largely mixed with clover. The total area is a little more than three acres. For the first crop we apply fertilizers at the following rates per acre: nitrate of soda, 150 pounds; muriate of potash, 200 pounds; fine-ground bone, 400 pounds.

For the purpose of the experiment with nitrate of soda, eight equal plots have been laid off, each containing almost exactly one-third of an acre. Alternate plots have annually received a top-dressing of nitrate of soda after the removal of the first crop during the past seven years. For the past four years, in order to facilitate the more even distribution of the nitrate, it has been mixed with sufficient basic slag meal to furnish an application of the latter at the rate of 400 pounds per acre; and to equalize conditions on the alternate plots to which no nitrate is applied, the slag meal is applied to all of these at the same rate. The results obtained the past season are presented in the table: —

Nitrate of Soda for Rowen.

Plots.	Fertilizers used (Rates per Acre).	Yields (Pounds).	Increase per Acre (Pounds).
Plot 1,	Slag meal, 400 pounds,	1,295	–
Plot 2,	Slag meal, 400 pounds; nitrate of soda, 150 pounds,	1,584	312
Plot 3,	Slag meal, 400 pounds,	1,249	–
Plot 4,	Slag meal, 400 pounds; nitrate of soda, 150 pounds,	1,493	160
Plot 5,	Slag meal, 400 pounds,	1,417	–
Plot 6,	Slag meal, 400 pounds; nitrate of soda, 200 pounds,	1,712	417
Plot 7,	Slag meal, 400 pounds,	1,173	–
Plot 8,	Slag meal, 400 pounds; nitrate of soda, 250 pounds,	2,285	1,112

The differences this year, although indicating a beneficial effect in every instance from the application of nitrate, are comparatively small except on plot 8. This is doubtless accounted for in large measure by the extreme drought which prevailed during the latter part of the summer. At current retail prices for nitrate during the past season its application did not prove profitable in any instance.

XI. — Poultry Experiments.

The poultry work of the past year has consisted in a repetition of the experiments in feeding for eggs which were carried out during the two preceding years. The general results of these experiments cannot perhaps be better expressed than in the following words, quoted from the nineteenth annual report: —

> The experiments had indicated: first, that, provided fat is abundant in the ration, high protein content is not essential; second, that, if the fat content of the ration is low, a large proportion of protein in the feeds used appears to be much more essential; and third, that a large proportion of fiber in the ration used is unfavorable to a good egg product.

The fowls used in the experiments of the past year were, as in previous years, pullets of our own raising. Carefully matched flocks were kept, as in former years, each in a house by itself, all of the houses being precisely similar in general dimensions and construction. The results of the past season's work are confirmatory in every particular of the results previously obtained. A somewhat full account of our experiments will be published in a bulletin which will be issued in the near future. I call attention here, therefore, only to what seem to be some of the more important practical conclusions. In estimating the reliability of these conclusions, it should be remembered that they are based upon results (on the whole in exact agreement throughout) which have been obtained in these long-continued experiments. These practical conclusions are as follows: —

1. When fat is abundant in the rations used in feeding fowls, a satisfactory egg product can be obtained by the use chiefly of grains which are relatively low in protein and high in carbohydrates. This means that corn may safely constitute a large proportion of the grain fed to laying fowls, and that it is not necessary, in order to secure a satisfactory egg product, to pay the higher prices usually demanded for wheat. It seems wiser to depend chiefly upon animal foods, such as beef scraps of good quality, to supply a fairly liberal proportion of protein and to enrich the ration in fat, using corn in connection with the scraps as the chief whole grain. A little wheat may be desirable, for the sake of variety, but to feed wheat as a source of protein seems unnecessary. Vegetable protein is not equal in value for egg production to protein derived from animal substances.

2. If, on the other hand, the combination of feeds used is low in fat, then a ration which furnishes abundant protein will prove considerably superior to one low in protein. If, for example, a dried animal meal from which the fat has been largely extracted, or such material as milk meal (milk albumen) made by the evaporation to dryness of separator skimmed milk low in fat, be used as sources of animal protein, then the combination of foods, including wheat in large quantity and therefore supplying protein in relative abundance, will give more eggs than a combination of foods in which corn, which furnishes less protein, is the principal grain. It has been clearly shown in investigations with domestic animals that in the process of digestion and assimilation the protein of the food may undergo changes resulting in the production of fat. If, as seems probable, the laws controlling metabolism in the digestive and assimilative processes of our domestic fowls are similar to those in the larger domestic animals, we find in this fact an explana-

tion of the difference in relative importance of wheat and corn in the rations of fowls with high and with low fat content. The body temperature of the domestic fowl is much higher than that of the larger domestic animals. To maintain this higher temperature, the oxidation in the body of relatively large quantities of heat producers must be essential. Among food heat-producers fat possesses not only the highest unit value, but is lowest in cost in proportion to value. It seems wise, therefore, in feeding fowls to introduce this nutrient into the ration as largely as is consistent with health. Beef scraps which have been carefully prepared, so that they are free from all bad odors or rancidity, and which contain a fairly large proportion of fat should be freely fed to laying fowls. They may not only with safety, but with positive advantage, be kept before such fowls all the time ; and if such scraps are so fed, then corn may safely be the principal grain used.

3. The domestic fowl has little or no ability to digest fiber. Our experiments have shown that a large proportion of fiber in the ration is unfavorable to egg production, other things being equal. The practice, therefore, of using such grains as oats, barley or buckwheat largely in the rations of laying fowls would seem to be unwise. Here again it may possibly in some cases be an advantage to use these grains in small amounts occasionally, for the sake of variety. The writer, however, is not a believer in this practice. He is able to obtain exceedingly satisfactory egg product while depending almost wholly upon corn, cracked or whole, as a grain ration, in connection with a mash including bran or middlings, linseed meal, corn meal and beef scraps.

REPORT OF THE HORTICULTURAL DIVISION.

F. A. WAUGH, HORTICULTURIST; CARL S. POMEROY, ASSISTANT HORTICULTURIST; E. A. WHITE, FLORIST.

The work in horticulture has followed the same lines as in recent years. Some additional problems have been undertaken, particularly in plant breeding, but there has been no change of general policy.

The experiments in pruning and in grafting have been continued, and have been combined with rather interesting results in the production and management of dwarf fruit trees. This subject just now commands a widespread interest, and the station has been able to be of considerable assistance to suburban residents, fruit growers, nurserymen and other planters of dwarf fruit trees. It has been thought best not to put out a special bulletin on this subject for the present, though a book on dwarf fruit trees, giving the results of our experience, has been published privately.

The station work in horticulture has been greatly strengthened during the year by the addition of some new men to the staff. Mr. C. S. Pomeroy of the University of Vermont has been placed in direct charge of all experimental work, and Prof. E. A. White of Storrs Agricultural College, Connecticut, has taken charge of the work in floriculture.

Notes on the Propagation of Apples.

F. A. WAUGH.

For several years the division of horticulture has been conducting experiments on the propagation of fruit trees, especially apples. For various reasons the so-called dwarfing stocks for apples (Doucin and Paradise) have been largely employed and carefully observed. Two objects have been kept most prominently in mind in these experiments : —

1. To observe as accurately as possible the effects of stock on cion, a field of study which has long been of great interest to horticulturists.

2. To determine the practical merits of different methods of propagation, with especial reference to the production of dwarf fruit trees.

While we have had a considerable quantity of material under study, and have been able to draw fairly satisfactory conclusions of a practical nature, it has been difficult to secure proper quantities of material under suitably uniform conditions for making exact scientific comparisons. The following data, however, seem to be safe and worthy of credit.

Comparison of Standard, Doucin and Paradise Stocks.

It should be explained at this point that "standard" apple stocks are the kind almost always employed in this country. They are grown mostly in the west and south, from seeds taken from apple pomace. These seedlings are then sold to nursery men in every part of the country, and are used as stocks for budding or grafting all varieties of apples.

Doucin stocks are mostly imported from France, where they are grown, not from seeds, but from mound layers or cuttings. They are somewhat slower growers than standard stocks, and when budded with common varieties produce trees of a semi-dwarf stature.

Paradise stocks are also grown chiefly in France, and in the same manner as the Doucin stocks. They are still dwarfer in character, and when budded with ordinary varieties produce very small trees. Some of these trees bear fruit abundantly at two or three years old, and appear to be mature at a height of 8 feet, or even less.

This difference in growth may be seen in the nursery to some extent, though usually the dwarfing effect of the Doucin and Paradise stocks is less obvious there than after the trees are planted in the orchard. This reservation is especially necessary in the case of the Baldwin apple, which shows a special aptitude for the Doucin stock. Yet the general influence of the different stocks is seen in a comparison of the growth of two-year-old nursery trees given below: —

Comparison of Baldwin Trees, Two Years Old.

	On Standard.	On Doucin.	On Paradise.
Number of trees, ...	89	47	37
Average height (centimeters), ...	166	116	98
Ratio of height to diameter, ...	103.8	82.9	70.0

The last of these figures, ratio of height to diameter, is the most significant. A small ratio indicates what the nurseryman calls a "stocky" tree. All the figures, however, indicate that considerable differences exist between the three lots of Baldwin trees propagated in the three different kinds of stocks.

However, averages are apt to be misleading, and they never tell the whole story. More information can be conveyed if we adopt the graphic method, as in Figs. 1, 2 and 3, in which each entire group of trees is represented. Here the very different characters of the curves, as well as their differing positions in their enclosing rectangles, indicate the very striking differences in the three lots of nursery trees. The tall, narrow, smooth curve in No. 2 shows that the trees on Doucin stocks were much more uniform than on the other two. As the short, stocky trees are placed at the left of each curve with the tall, slim ones at the right, it is easily seen that the trees on Paradise were much stockier than those on Doucin, and those on Doucin were in turn shorter and stockier than those on ordinary stocks.

BALDWIN APPLE TREES. — Two years old.

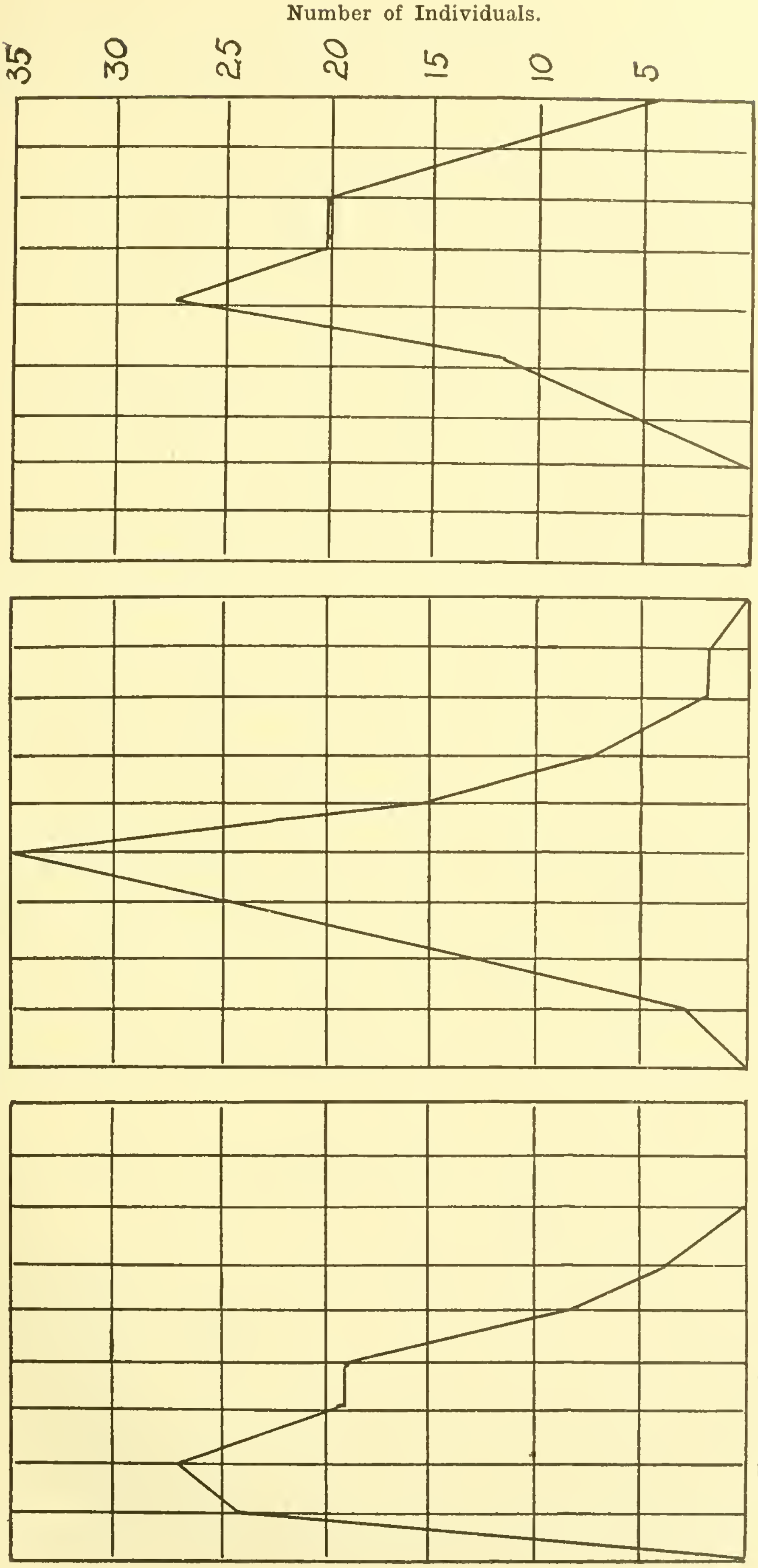

Fig. 1. — On Paradise stocks.

Fig. 2. — On Doucin stocks.

Fig. 3. — On standard stocks.

Diagrams showing the variation in Baldwin apple trees as grown on different stocks. Each curve represents the distribution of 100 trees into classes, according to the ratio of diameter to height. The smaller ratios are at the left, beginning with a ratio of 50 (height ÷ diameter = 50), progressing by 10's and ending with a ratio of 140. Horizontal lines represent numbers of individuals in each class.

These results agree with the common belief regarding the influences of the different stocks; but so far as we know these influences have never before been carefully demonstrated and measured.

The same differences are shown between trees of other varieties, such as Wealthy, McIntosh, Greening, etc., when grown on the different kinds of stocks. Unfortunately, we do not have a series of varieties growing on all three stocks, under uniform conditions and of the same age, so as to make an extended comparison. However, the following averages of two additional lots on Paradise and Doucin stocks will indicate the generally uniform character of the influence of these stocks: —

Comparison of Two-year-old Nursery Trees.

	On Doucin.	On Paradise.
Wealthy: —		
Number of trees,	84	51
Average height (centimeters),	165	128
Ratio of height to diameter,	110.0	98.5
McIntosh: —		
Number of trees,	73	50
Average height (centimeters),	148	154
Ratio of height to diameter,	106.4	96.2

Variation in Peas.

F. A. WAUGH; C. S. POMEROY.

Two new ideas, of the magnitude of great discoveries, recently brought to the front in the scientific world have developed an entirely new interest in plant breeding. This new interest has manifested itself both in practical plant-breeding work and in renewed scientific investigation. The two ideas here referred to are: (1) Mendel's law, so called; and (2) the statistical method of studying variation and heredity.

The horticultural division of the Massachusetts Agricultural Experiment Station has been engaged for several years in certain investigations in both these fields. On account of the length of time required to secure definite results, no report has yet been made of these experiments, but a brief report of some of the partial figures may be of interest at this time, particularly by way of illustrating the modern methods of study.[1]

For the purposes of this particular study, one row of peas was staked off in the middle of a field. A careful record was kept of each vine, showing its length, the number of pods borne, the length of the pods and the number of peas in each pod. The variation is shown by the following figures: —

Variation in Peas.

	Minimum.	Maximum.	Average.
Number of vines,	179	–	–
Length of vines (centimeters),	20	88	54.70
Number of pods per vine,	1	13	4.68
Length of pods (centimeters),	2	9.5	6.88
Number of peas per pod,	–	9	3.46

[1] The statistical methods of study and graphic methods of presenting data have been developed especially in England by Francis Galton and Prof. Karl Pearson. In this country the same methods have been presented by C. B. Davenport and by E. Davenport, dean of the Illinois College of Agriculture, in his recent book, "Principles of Breeding." It seems better to refer the student of plant breeding to these works, rather than to attempt a more extended explanation of these somewhat complicated methods in this report.

These figures, however, give only very meager information as to the whole range of variation, even in the qualities studied. If we wish to know the facts more accurately, we should refer to the graphic presentation on pages 66, 67 and 68.

Let us study first Fig. 1, showing the variation in length of vine. The spaces along the bottom of the figure represent different lengths of vine, in centimeters. The vertical spaces

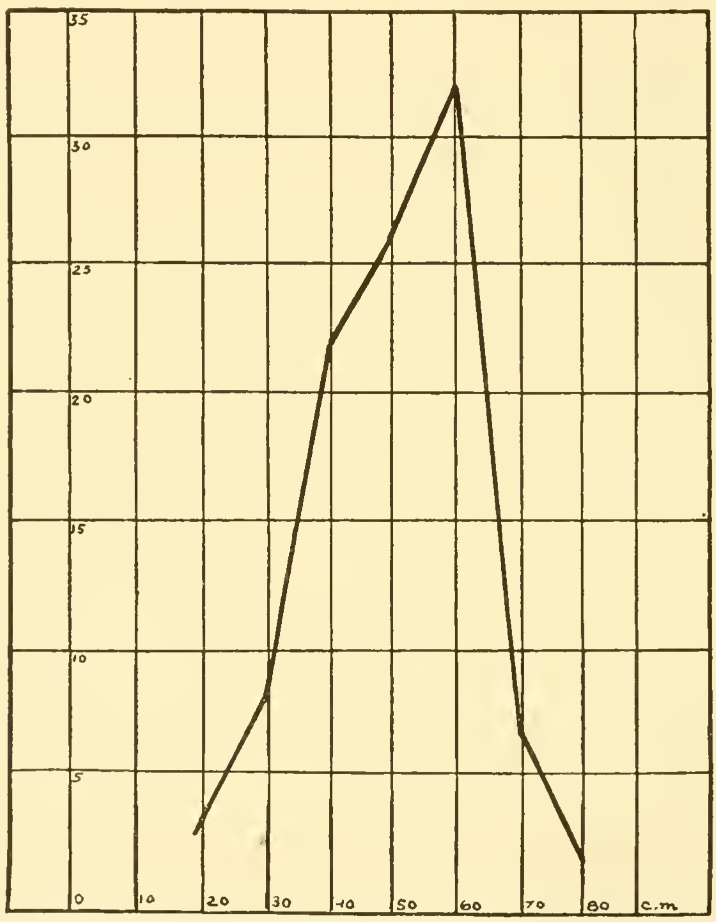

FIG. 1.

represent the number of vines of each length, the whole being represented on a percentage basis; *i.e.*, 179 vines as 100. It will be seen that in each 100 vines there were 3 having a length of 20 centimeters, 8 with a length of 30 centimeters (26–35 centimeters), 22 with a length of 40 centimeters, 32 with a length of 60 centimeters, 7 with a length of 70 centimeters and 2 with a length of 80 centimeters. The figure thus shows the composition of the entire row (the "population," as it is technically called) with respect to height.

One of the most important facts brought out by this graph is that, while the average length of vine is 54.7 centimeters the largest number of vines have a height of 60 centimeters. This shows that the typical Excelsior pea vine in this field was nearly 10 centimeters taller than the average; or, to put the matter another way, a relatively large number of vines run below the typical height.

We may now direct our attention to the number of pods to

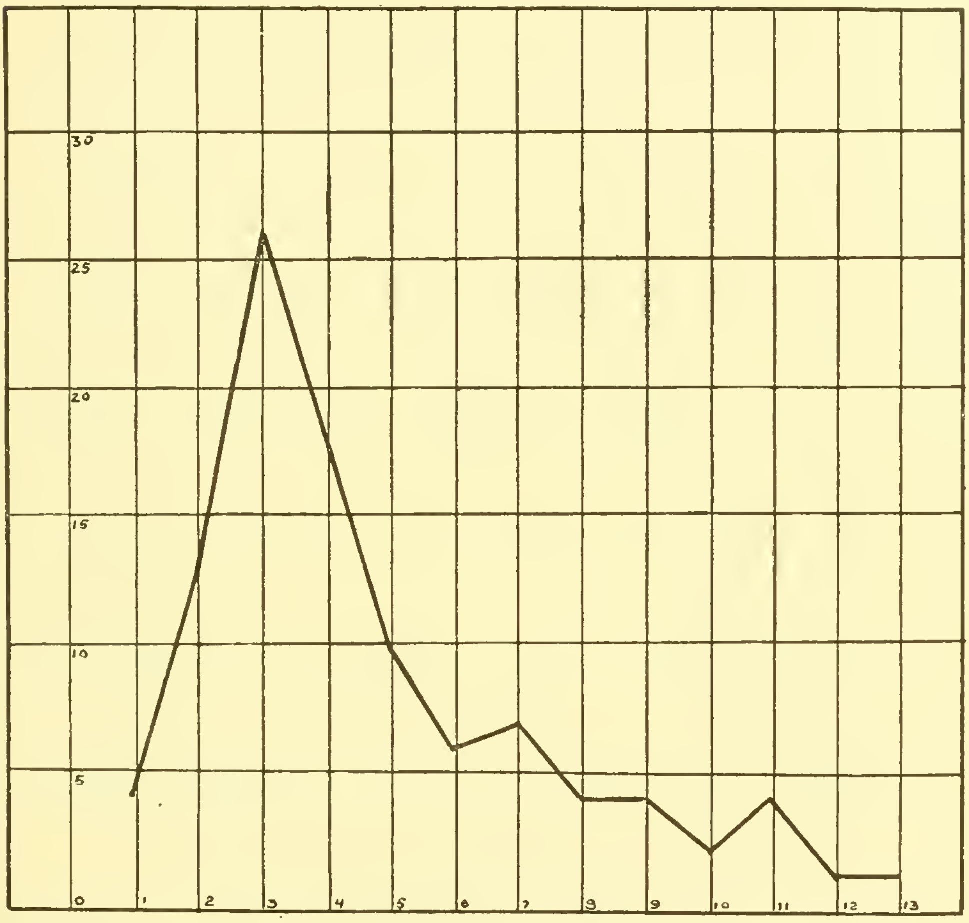

FIG. 2.

the vine. These are shown by Fig. 2. From this we see at once that the typical vine in this field (*i.e.*, the kind of vine most frequently found) contains 3 pods, while the average number is 4.68. This average is brought up by a few vines, represented at the right of the curve, bearing an unusually large number of pods.

At this point it might be suggested that the practical plant breeder, in an endeavor to improve this variety of peas, would naturally select seed from those vines bearing 8, 9, 10 or more pods.

Fig. 3 gives the curve representing the variation in number of peas, to the pod. Two pods in each 100 at the average had no peas, while one in 100 had 8 and one had 9. The average was 3.46, but the typical pod contained 4 peas, — distinctly more than the average.

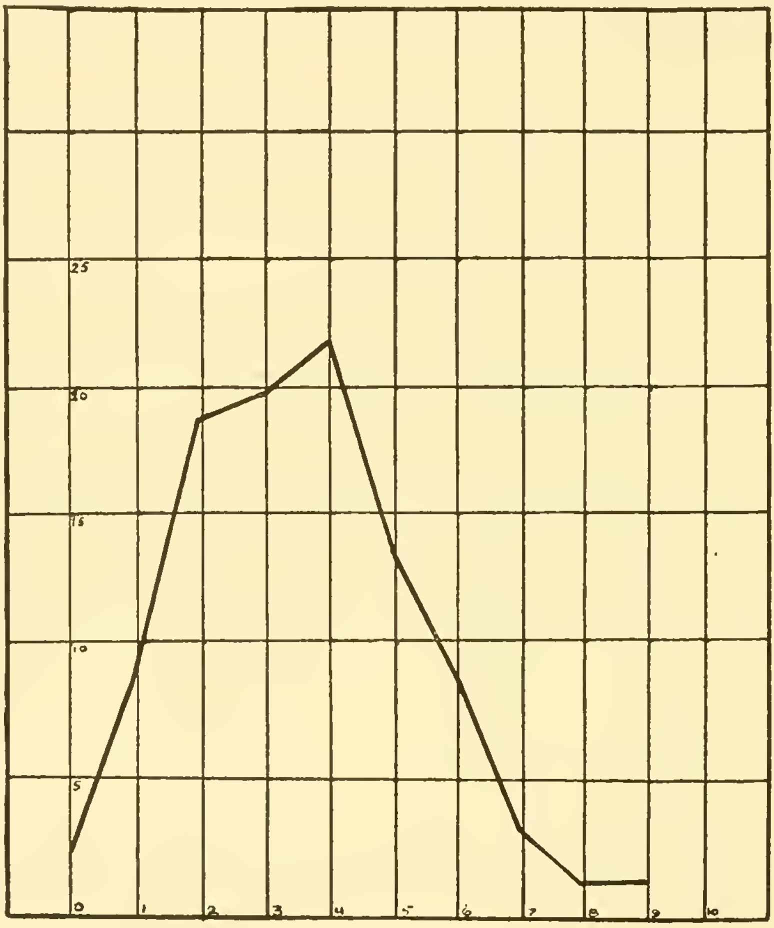

FIG. 3.

Turning once more to the requirements of the practical plant breeder, we see that he would wish to grow the largest number of peas to the pod, as well as the largest number of pods to the vine; and the question arises immediately, whether these two qualities are compatible. Do the vines bearing the largest number of pods bear also the largest number of peas to the pod? or are the pods with the largest number of peas borne on the vines having relatively few pods?

Studies in Correlation.

These questions bring us immediately to the study of correlation in variation, — one of the most important fields of plant study. In no field, moreover, is the value of the statistical method more conspicuous than in this.

There are two algebraic methods of answering the questions just asked, the first known as Yule's method,[1] and the second may be called Pearson's method [2] or the method of compound series. In applying the former method it is necessary to separate the plants into four groups, according to the two characters to be compared.

If we select those vines which bear 8 pods each or more, putting them in one class, with those bearing 7 pods or less in another class, and if we then subdivide each of these classes according to the average number of peas per pod on each vine, we shall have the following groups and figures : —

	8 Pods or More.	7 Pods or Less.
3.6 peas per pod or more, ...	9	66
3.5 peas per pod or less, ...	19	85

From which the following computation is made according to Yule's formula : —

$$\frac{(66 \times 19)-(9 \times 85)}{(66 \times 19)+(9 \times 85)}=\frac{489}{2019}=+0.242.$$

Showing a correlation of character in these groups of over 24 per cent.

Now, if the arbitrary division is made between vines bearing 7 pods or over and those bearing 6 pods or less, the rest of the computation following as before, we find the coefficient of correlation reduced to — 0.067 ; or with the division made between vines bearing 5 pods and those bearing 4, the coefficient of correlation becomes — 0.0126, showing a very little or slightly negative correlation in these groupings.

[1] See E. Davenport, "Principles of Breeding."
[2] See C. B. Davenport, p. 456, 1907, "Statistical Methods."

In plain language, it appears that the few vines bearing an abnormally large number of pods bear also an abnormally large number of peas to the pod. These would certainly be the vines which the pea grower would select in improving his stock toward greater prolificacy.

If the whole number of vines is studied in one view, without arbitrary division into classes, by the method of compound series, the correlation coefficient is found to be — 0.0176,[1] a number so small as to be entirely negligible.

While the results involved are of less practical interest, it may be worth while to give the results of other correlation studies with this same material. For instance, we may study the correlation existing between the length of vine and the number of peas per vine.

Of course we would expect the taller vines to bear the largest number of pods and of peas; and, in fact, the mathematical computation shows a correlation coefficient of +0.668[2] when it is understood that a coefficient of +1.0 shows the highest correlation that can exist, and indicates two characters absolutely dependent on one another, it will be seen that +0.668 indicates very close relationship between length of vine and number of peas borne.

If we compute in a similar manner the relation existing between the number of pods per vine and the total number of peas per vine, we find a correlation coefficient of +0.897.[3]

These peas will be made the basis of further breeding experiments, and a comparison of future generations with the crop of 1907 may be expected to develop new points of interest.

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[1] Standard deviation, pods per vine, 2.64; peas per pod, 1.14.
[2] Standard deviation, length of vine, 10.5; peas per vine, 10.3.
[3] Standard deviation, pods per vine, 2.64; peas per vine, 10.3.

The Physiological Constant for the Germinating Stage of Cress.

F. A. WAUGH; C. S. POMEROY.

The subject of physiological constants was studied several years ago by the senior writer, and a report of certain investigations made, to which the reader is referred for summaries of the theories advanced by various investigators.[1] A brief statement of the present accepted belief is here given, that the subject may be properly understood by all.

A physiological constant may be defined as the amount of heat required to carry a plant through some certain stage of its growth. Thus each species of plant and each phase of development for each species would have its own physiological constant.

De Candolle,[2] writing over fifty years ago, set forth two fundamental principles which are accepted as sound to-day: "1. The active heat is the product of the degree of temperature and its duration. A more intense heat in a short time produces the same effect as a less intense heat in a longer time. This is true, provided the range of temperature and the space of time are limited. 2. Every plant requires a certain minimum of heat for each of its physiological functions, as germinating, leafing, flowering, etc. The temperatures below freezing point have no effect on plants, or at a certain low degree a destroying one; but there are many species on which the lower degrees above the freezing point have no effect. There is a starting point of vegetation for every species at a certain degree of temperature; every species requires a certain sum of heat above a certain degree of temperature, distributed over a certain space of time between a minimum and a maximum of

[1] F. A. Waugh, Vermont Agricultural Station report, II. (1898), pp. 263–272.

[2] Alphonse De Candolle, "Géographie Botanique" (1855).

duration." This minimum of temperature, which must be reached before any development takes place, has been called the critical temperature. De Candolle considered 43° as the critical temperature for all plants. Previously it had been placed at the freezing point. Now it is known that this point varies for different species and varieties, and for different functions.

The theory as above stated assumes as the constant the sum total of temperatures above a certain minimum point for the elapsed time. Such a constant is of use in places having similar climates, but obviously is not suitable for comparisons between places having different lengths of growing seasons; for plants of the same species come to maturity in northern latitudes with a very much less sum of heat than in more southern locations. In order to correct this inaccuracy, Linsser[1] proposed the aliquot idea. To determine the aliquot for any physiological function, the sum temperature for the given phase is divided by the sum temperature for the entire year, as observed at the same station. Thus, instead of depending upon the production of a certain constant *sum* of heat, certain stages are considered as due to be completed when the sum temperatures above the critical temperature equal a definite *fraction* of the sum temperature of the year. Linsser called this fraction the physiological constant.

Another question is presented by this study of the aliquot, namely: Is the critical temperature constant for a given function and species in different latitudes? No investigations are known which have sought to determine this point, but theoretically it must be answered in the negative, as a little thought will show. If we consider this constant to be the same in all latitudes, how can we conceive of certain trees and shrubs having any dormant periods in locations where the temperature rarely falls as low as that at which they bloom in our northern climate? That is, the temperature is continually above the critical temperature, and no chance is offered for the plants to rest.

Heretofore all investigations of this subject have depended upon thermometer readings for their measurements of the sum temperatures. These readings were taken two or three times a

[1] Carl Linsser, "Die Periodische Erscheinungen des Pflanzenlebens in ihrem Verhaeltniss zu den Waermeerscheinungen." Mem. Acad. Sci., St. Petersb., sev. VII., 11 (1867), No. 7, p. 35.

day, their mean found, and that figure employed as the temperature of the day. This method has given results which were obviously very inaccurate as to the sum of heat for the time, and much more variable on some days than on others. However, in comparing different sets of observations taken in this same manner, the variations have averaged up with each other fairly well and relatively correct comparisons could be made.

For several years the division of horticulture has been carrying forward a series of investigations in this field by methods not hitherto applied to this interesting subject. The novelty and value of our methods consist in their being very much more accurate than any previously employed. Instead of depending on public meteorological reports for the computation of accumulated temperatures, we have employed the recording thermograph. This instrument makes a complete and continuous record, showing exactly the quantities of heat to which it has been exposed.

Greater accuracy was secured, secondly, by placing the thermograph in close proximity to the plants under observation. The temperatures recorded are therefore the exact temperatures to which the plants were subjected. When it is understood that previous investigators have been forced in many cases to accept meteorological records taken many miles from the plants under observation, it will be seen that this feature of our work constitutes a considerable improvement.

In the third place, much greater accuracy was secured in methods of computing sum temperatures. Having a perfect record from the thermograph, there remained only the problem of securing an exact measurement of the heat quantities thereon represented. This problem was solved by the use of the planimeter. The thermograph record appears in the form of an irregular line having a generally horizontal direction. If the height of this line, representing degrees of temperature, be measured from some base line (as, *e.g.*, the zero of the thermometer), we may readily construct a figure which offers an exact geometrical representation of the quantity of heat which we seek to measure. Such figures are shown in Fig. 1. Horizontal distances represent degrees of heat; so that the product of length by height, giving the area of the figure, gives also the quantity of accumulated heat.

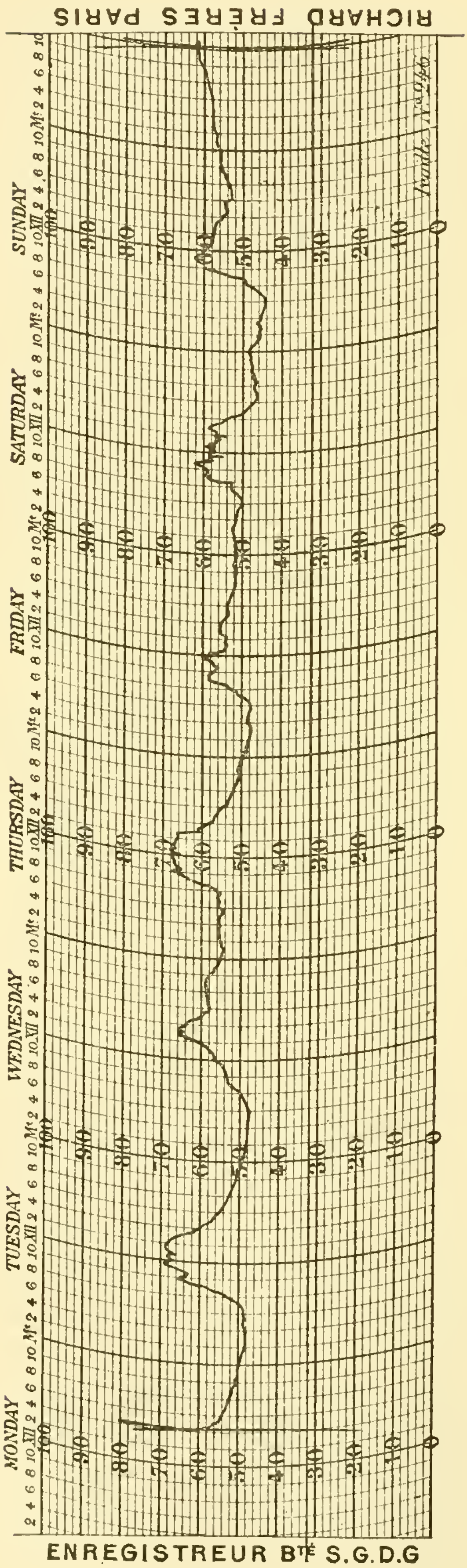
RICHARD FRÈRES PARIS
MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SATURDAY
SUNDAY
ENREGISTREUR Bté S.G.D.G

FIG. 1.

In our work we have used a Coradi rolling sphere planimeter, which is one of the most reliable and accurate styles of planimeter in the market.

In seeking to apply the method here outlined to the actual determination of specific physiological constants, the first requisite was a plant which would pass through its various stages rapidly, so that a number of observations could be made in a comparatively short time; the phase in question must be one easily reproduced, and several individuals of the same age should be under observation at the same time, in order that the length of time required for the completion of the phase may be noted for a greater number. The germination stage of common curled cress was chosen for observation, as it seemed to satisfy the required conditions. Germination is rapid at ordinary temperatures, and is very uniform, and the phase can be studied at all seasons of the year, out of doors or in the greenhouse.

During the past few months 77 thermograph records have been obtained of this phase, and tabulated for study. In these records the sum temperatures above 32° have varied from 2,714 to 4,286, and the time occupied for the completion of the stage from 70 to 210 hours. The problem now, with these figures before us, is to determine at once two unknown quantities: first, the critical temperature; and second, the constant quantity of heat above that temperature required to complete the germination phase in the cress plant.

The method of making this computation will be readily

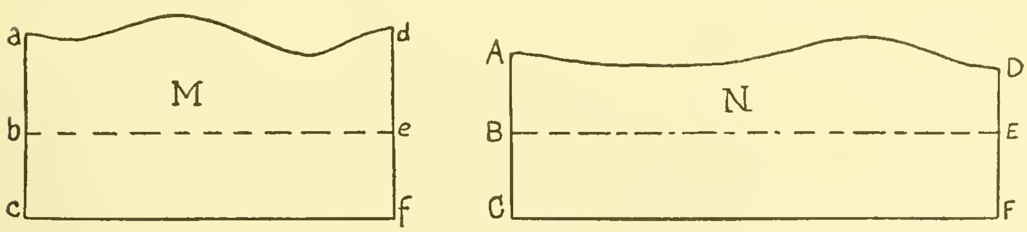

FIG. 2.

understood from the diagram (Fig. 2). The figure M represents one thermograph record for one experiment, and the figure N another record for another experiment. The lines c f and C F represent the 32° or base line. The irregular lines a d and A D represent the temperature trace. The lines b e and B E represent the critical temperature. Temperatures below b e and B E are assumed to have no effect on the germination of the cress seeds. It is required first to determine the height of b e above c f, which height is assumed to be the same as the height of B E above C F.

According to our assumptions, the area of the figure a b e d is equal to the area of the figure A B E D. If we let the height b c = B C = x; and if we let the elapsed time in hours for figure M represented by c f = y; and let the elapsed time in hours for figure N be represented by C F = y'; then allowing m to represent the total sum temperature for the figure M = (a c f d), and n to represent the total sum temperature above zero recorded in the figure N (A C F D), we may form the following algebraic equation :—

$$m - yx = n - y'x$$

$$(y - y')x = m - n$$

$$x = \frac{m - n}{y - y'}.$$

As the quantities m, n, y and y' are all directly measurable on any two thermograph records thus compared, x may be easily computed in concrete numbers.

Some difficulty arises in the use of this formula for determining the value of x, as when any single thermograph record is compared successively with several others taken at random, decidedly irregular results follow. Values for x can be found varying all the way from $-1°$ to $+60°$; and though the majority of values lie between 5° and 10°, there is still too great variation to make the result satisfactory. This comparatively great variation is due, however, not to any essential inaccuracy in the method, but the smallness of the numbers employed.

In order to get rid of the relatively great variations shown in individual comparisons and to find a reliable average for the whole body of records, these records were plotted as shown in Fig. 3. Here each dot shows the result of a single experiment, referred to a horizontal axis for time and to a vertical axis for accumulated temperature. The distribution of these dots demonstrates at once the practically uniform character of the results.

It is now an easy matter to draw the line A B, forming the axis along which these dots cluster, and which may be assumed to be the theoretical locus of them all.

Having now this average of values shown in the line A B, we may take any time values, as 100 hours and 150 hours, and find immediately the corresponding sum temperatures, — 3,140

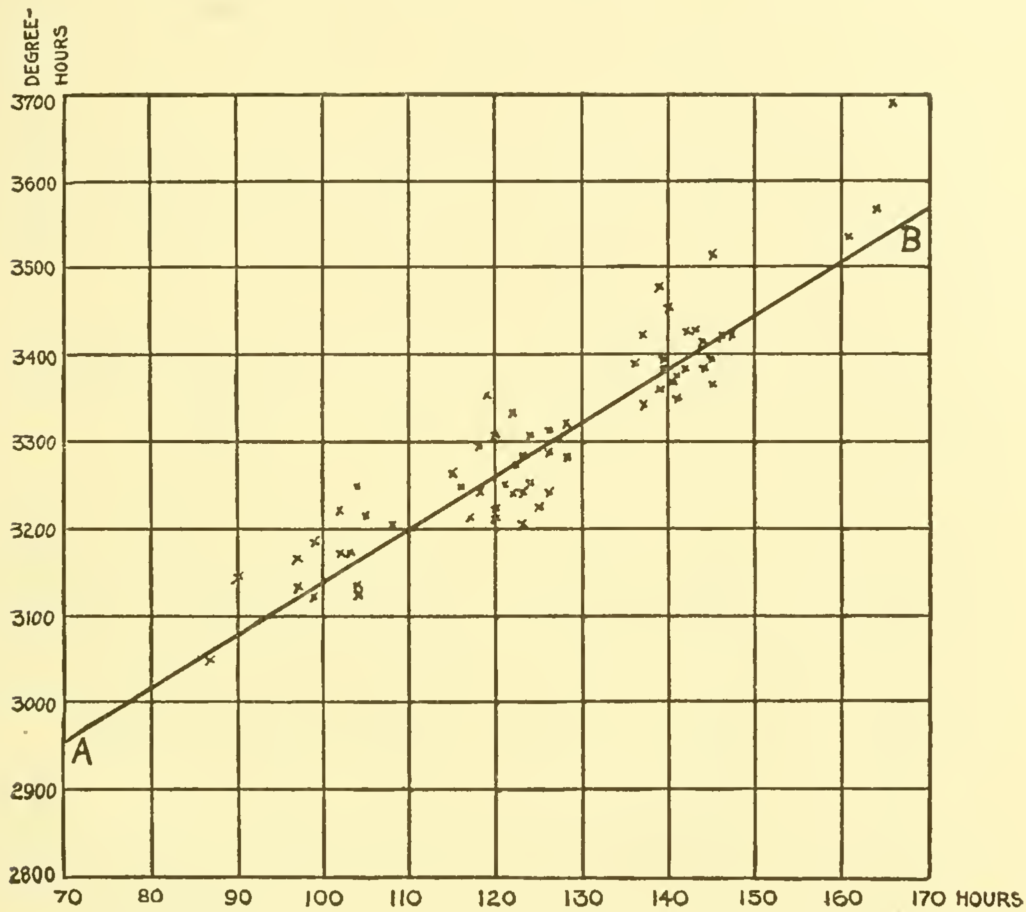

Fig. 3.

and 3,445 degree-hours. Substituting these values in the equation already formed, we find the value of x to be 6.2°. Adding this amount to 32°, the base from which we are computing, we have 38.2°, the critical temperature for the germination phase of cress.

The constant sum temperature above 38.2° required for the germination of cress should now be easily found by subtracting from each sum temperature as taken the amount of temperature intervening between 32° and 38.2°. This is secured simply by multiplying the elapsed time by 6.2°.

Applying this method to the records in hand, we find that fairly constant results are secured, according to our expectations. The records at the extreme ends of the scale, especially at the upper end, deviate considerably from the average, but this was to have been expected, and for present purposes these records may fairly be excluded. It seems proper further to throw out three or four other records which on account of excessive deviation are open to suspicion. With these apparently abnormal records temporarily eliminated (they are to be studied further in additional experiments), we secure results which are rather remarkably uniform. Thus, the constant sum temperature being computed to be 2,530 degree-hours, the extreme deviation is less than 100, and the standard deviation is only 36.6°. The probable error is only 24.7°.[1]

Thus, the temperature being known, and lying within reasonable limits, the germination period of cress can be computed in advance within a range of approximately two hours.

The tabulated records used in these computations are appended to this report.

A few abnormal records have been reserved for further study, and there have arisen one or two intricate questions relating to the whole theory of the physiological constant which must be investigated further; but as the figures stand they seem to represent a considerable advance in this interesting field.

Tabulation of Thermograph Records.

Elapsed Time (in Hours) for Germination Phase of Cress.	Accumulated Temperature, in Degree-hours.	
	Above 32°.	Above 38.2°.
87,	3,054	2,516
90,	3,148	2,590
97,	3,135	2,533
97,	3,164	2,562
98,	3,126	2,518
99,	3,186	2,572
100,	3,127	2,507
102,	3,221	2,589
103,	3,173	2,535

[1] "Standard deviation" is the geometric mean of deviations. "Probable error" is defined as that departure from the mean, on either side, within which exactly one-half the variates are found.

Tabulation of Thermograph Records — Continued.

Elapsed Time (in Hours) for Germination Phase of Cress.	Accumulated Temperature, in Degree-hours.	
	Above 32°.	Above 38.2°.
104,	3,253	2,608
104,	3,126	2,481
105,	3,217	2,566
108,	3,205	2,536
115,	3,263	2,550
116,	3,249	2,530
117,	3,216	2,491
118,	3,245	2,513
118,	3,296	2,564
119,	3,352	2,614
120,	3,311	2,567
120,	3,214	2,470
120,	3,217	2,473
121,	3,253	2,503
122,	3,241	2,485
122,	3,336	2,570
123,	3,246	2,484
123,	3,206	2,444
123,	3,283	2,521
124,	3,309	2,541
124,	3,285	2,517
124,	3,258	2,490
125,	3,228	2,463
126,	3,290	2,509
126,	3,241	2,460
126,	3,316	2,535
128,	3,286	2,492
128,	3,310	2,516
136,	3,394	2,550
137,	3,341	2,491
137,	3,427	2,577
139,	3,479	2,617
139,	3,385	2,523
139,	3,398	2,536
139,	3,362	2,500
140,	3,376	2,508

Tabulation of Thermograph Records — Concluded.

Elapsed Time (in Hours) for Germination Phase of Cress.	Accumulated Temperature, in Degree-hours.	
	Above 32°.	Above 38.2°.
140,	3,451	2,583
141,	3,350	2,476
141,	3,372	2,498
142,	3,428	2,548
142,	3,381	2,501
143,	3,431	2,545
144,	3,417	2,524
144,	3,384	2,491
145,	3,397	2,538
145,	3,367	2,508
146,	3,425	2,520
147,	3,423	2,511
161,	3,536	2,538

Constant sum temperature, ... 2,530 degree-hours.
Standard deviation, ... 36.6°
Probable error, ... 24.7°

REPORT OF THE CHEMIST.

DEPARTMENT OF PLANT AND ANIMAL CHEMISTRY.

JOSEPH B. LINDSEY.

Research division: E. B. Holland and R. D. MacLaurin.
Fertilizer division: H. D. Haskins, E. T. Ladd,[1] W. E. Dickinson.[2]
Feed and dairy division: P. H. Smith and L. S. Walker.
Inspection of fertilizers, feeds and Babcock machines: W. K. Hepburn.
In charge of feeding experiments: R. F. Gaskill.
Clerk and stenographer: Harriet M. Cobb.

Part I. — The Work of the Year briefly outlined.

1. Correspondence.
2. Numerical summary of laboratory work.
3. Execution of the fertilizer law.
4. Miscellaneous fertilizers, soils and by-products for free analysis.
5. Execution of the feed law.
6. Milk, cream and feeds sent for free examination.
7. Execution of the dairy law.
8. Sanitary analysis of drinking water.
9. The testing of pure-bred cows.
10. Special chemical work.
11. Work completed.
12. Work in progress.

Part II. — Dairy and Chemical Studies.

1. The chemical composition of milk.
2. The effect of food on the composition of milk and butter fat, and on the consistency or body of butter.
3. Standard for Babcock glassware.

[1] Resigned Jan. 1, 1908. [2] Resigned Dec. 1, 1907.

Part I. — The Year's Work briefly outlined.

J. B. LINDSEY.

On July 1, the division of foods and feeding and the fertilizer division were united, and termed the department of plant and animal chemistry.

A new division was created, to be known as the research division. This latter division will devote itself to the study of problems in animal nutrition and investigations in plant and animal chemistry.

The fertilizer division takes charge of the annual inspection of commercial fertilizers, examines samples of fertilizers, refuse manurial substances and soils sent to the station, and will devote the remainder of its time to other problems either of a control or research nature.

The feed and dairy division has charge of the execution of the feed and dairy laws, examines samples of water, supervises the testing of pure-bred cows, analyzes samples of feed stuffs and dairy products connected with experiments in progress at the station as well as those sent in for examination.

A brief outline of the work follows, and includes that of the two separate divisions *previous* to the reorganization.

1. Correspondence.

The enactment of an amendment to the fertilizer law, requiring the publication of station valuations, the local dealer's retail cash price and the percentage difference between the two, has noticeably increased the correspondence during the past year. In addition to the above, a large number of letters has been received and answered relative to problems connected with fertilizers, feed stuffs and dairying. Numerous analyses of fertilizers, feed stuffs, dairy products and water have been reported directly to the manufacturers, local agents and private persons. The estimated number of letters of all kinds sent out from Dec. 15, 1906, to Dec. 1, 1907, — eleven and one-half months, — approximated 5,395.

2. Numerical Summary of Laboratory Work.

From Dec. 15, 1906, to Dec. 1, 1907, there have been received and examined 99 samples of water, 529 of milk, 1,732 of cream, 135 of feed stuffs, 176 of fertilizers and fertilizer materials, 48 soils and 21 miscellaneous. In connection with experiments made by this and other departments of the station, there have been examined 338 samples of milk, 40 samples of cream, 52 samples of butter, 68 samples of butter oil, 111 samples of cattle feeds, 336 samples of agricultural plants, 31 samples of soils and 32 samples of fertilizers. There have also been collected and examined 841 samples of cattle feeds in accordance with the requirements of the feed law, and 513 samples of fertilizer in accordance with the fertilizer law. The total for the year has been 5,102.

In addition to the above, twenty-one candidates have been examined and given certificates to operate Babcock machines, and 3,082 pieces of Babcock glassware have been tested for accuracy of graduation, of which 204, or 6.62 per cent., were inaccurate.

3. Execution of the Fertilizer Law (Acts of 1896, Chapter 297, and 1907, Chapter 289).

Since July 1, Mr. H. D. Haskins has assumed charge of this work, and has carried it forward with energy and perseverance. Mr. Haskins submits the following report: —

A new fertilizer act, passed by the State Legislature and approved April 11, 1907, reads: —

Be it enacted, etc., as follows:

Section 1. The bulletins or other publications of the Massachusetts agricultural experiment station containing information about fertilizers shall, in all cases, state the dealers' cash price per ton for such fertilizers, the value per ton of the ingredients of the same, and the percentage of difference between the said price and the said value.

Section 2. This act shall take effect upon its passage.

In compliance with the above act, the necessary data have been collected, and fertilizer Bulletin No. 119 gives, in detail, the required information as well as the method employed in obtaining the same.

During the season 513 samples, representing 358 distinct brands, have been analyzed and the results have been published. (See Bulletin No. 119, December, 1907.) Forty-five more licensed brands were analyzed than during the previous year. Seventy-seven manufacturers, importers and dealers have secured licenses for 317 distinct brands of fertilizer during 1907.

Samples were taken in about 80 different towns and cities in the State. Of the 358 brands analyzed, 275 were complete fertilizers; 38 were materials furnishing nitrogen and phosphoric acid, such as ground bone, tankage and dry ground fish; 14 were potash compounds; 9 were phosphoric acid compounds; 15 were compounds furnishing nitrogen; and 7 were compounds furnishing potash and phosphoric acid.

Trade Values of Fertilizing Ingredients for 1907.

	Cents per Pound.
Nitrogen: —	
In ammonia salts,	17½
In nitrates,	18½
Organic in dry and fine-ground fish, meat, blood, and in high-grade mixed fertilizers,	20½
Organic nitrogen in fine bone and tankage,	20½
Organic nitrogen in coarse bone and tankage,	15
Phosphoric acid: —	
Soluble in water,	5
Soluble in ammonium citrate (reverted),	4½
In fine bone and tankage,	4
In coarse bone and tankage,	3
In cotton-seed meal, linseed meal, castor pomace and wood ashes,	4
Insoluble (in neutral citrate of ammonia in mixed fertilizers),	2
Potash: —	
As sulfate, free from chloride,	5
As muriate (chloride),	4¼
As carbonate,	8

The above prices were made up from quotations obtained for the six months preceding March 1, 1907, and actually show the price at which the various ingredients were retailed in markets at centers of distribution in New England, New York and New Jersey.

The average comparative commercial value of the 275 brands of complete fertilizer analyzed was $24.19, the average retail cash price $35.40 and the percentage of difference 44.85.

Of the 275 brands, 113, or about 41 per cent., failed to meet the manufacturers' guaranty in some one or more of the essential elements; many of these deficiencies were made up by an excess of some one or more of the other essential ingredients. Twenty-one of the samples of complete fertilizers, however, showed a commercial shortage ranging from 79 cents to $13.50 per ton.

Eighty-six brands were deficient in one, 23 in two and 4 in all three of the essential elements of plant food. Seventy were deficient in nitrogen, 43 in potash and 28 in phosphoric acid.

Among the 38 brands of ground bone, tankage and dry ground fish, 16 failed to meet the guaranty in nitrogen and 4 in phosphoric acid; only a few of these brands, however, show a commercial shortage. The average retail cash prices, valuations and percentages of difference of the ground bones, dissolved bones, tankages and dry ground fish were as follows: —

	Retail Cash Price.	Valuation.	Percentage Difference.
Ground bone,	$29 46	$27 45	7.32
Dissolved bone,	25 50	25 03	1.88
Tankage,	21 67	29 93	27.60 [1]
Dry ground fish,	39 00	39 89	2.23 [1]

[1] Valuation in excess of selling price.

In case of chemicals and other raw materials, it may be said that 2 samples of nitrate of soda, one sample of dried blood and 5 samples of cotton-seed meal failed to meet the nitrogen guaranty. Two samples of muriate of potash and one sample of carbonate of potash did not meet the potash guaranty. One sample of superphosphate, 1 sample of dissolved bone black and 2 samples of dissolved phosphates and potash fell below the phosphoric acid guaranty.

Cost of One Pound of Nitrogen, Phosphoric Acid and Potash in Raw Materials.

	Cents.
Nitrogen: —	
From nitrate of soda,	19¼
From dried blood,	22½
From cotton-seed meal,	23⅗
From linseed meal,	24⅖
From castor pomace,	23¼
Potash: —	
From carbonate of potash,	8
From sulfate of potash,	5⅖
From muriate of potash,	4½
Available phosphoric acid: —	
From dissolved bone black,	7½
From acid phosphate,	5⅕

A pound of total phosphoric acid in "Thomas slag phosphate" has cost the consumer on the average about 5 cents.

Summary of Analyses of Complete Fertilizers, 1907.

The table below shows the comparative quality of the brands of complete fertilizer analyzed during the year, and gives the following information concerning each manufacturer: (*a*) the number of brands of complete fertilizer collected and analyzed; (*b*) the number of brands in which all three of the essential ingredients of plant food are equal to the lowest guaranty; (*c*) the number which do not show a commercial shortage, including those fertilizers where a deficiency of any one element is offset commercially by an excess of some of the other essential ingredients; (*d*) the per cent. of the whole number of complete fertilizers sold by each company not having a commercial shortage. The last three columns indicate the number of brands deficient in one, two and in all three of the essential elements of plant food.

TABLE I.

MANUFACTURER.	Number of Brands Analyzed.	Number with all Three Elements equal to Lowest Guaranty.	Number equal to Guaranty in Commercial Value.	Per Cent. of Brands not showing a Commercial Shortage.	Number with One Element below Lowest Guaranty.	Number with Two Elements below Lowest Guaranty.	Number with Three Elements below Lowest Guaranty.
W. H. Abbott,	3	1	3	100.00	2	–	–
American Agricultural Chemical Company.	61	45	58	95.08	14	2	–
Armour Fertilizer Works,	10	8	10	100.00	1	1	–
Beach Soap Company,	3	1	2	66.66	2	–	–
Berkshire Fertilizer Company,	4	2	4	100.00	2	–	–
Bonora Chemical Company,	1	–	1	100.00	1	–	–
Bowker Fertilizer Company,	33	19	29	90.00	8	6	–
J. Breck & Son,	4	1	1	25.00	3	–	–
Buffalo Fertilizer Company,	4	–	1	25.00	3	1	–
Coe-Mortimer Company,	7	2	3	42.85	4	1	–
Eastern Chemical Company,	1	–	1	100.00	1	–	–
Eureka Liquid Fertilizer Company,	1	–	–	–	–	–	1
R. & J. Farquhar & Co.,	5	4	4	80.00	–	1	–
Fertilizer Products Company,	1	1	1	100.00	–	–	–
C. W. Hastings,	1	–	–	–	1	–	–
Lister's Agricultural Chemical Works,	7	5	6	85.71	2	–	–
Mapes Formula & Peruvian Guano Company.	16	12	16	100.00	4	–	–
Mitchell Fertilizer Company,	1	–	1	100.00	1	–	–
National Fertilizer Company,	15	8	13	86.66	5	2	–
New England Fertilizer Company,	7	4	6	85.71	2	1	–
Olds & Whipple,	4	3	4	100.00	1	–	–
Parmenter & Polsey,	2	2	2	100.00	–	–	–
R. T. Prentiss,	3	–	–	–	–	1	2
Benjamin Randall,	2	1	2	100.00	–	1	–
W. W. Rawson & Co.,	3	3	3	100.00	–	–	–
Rogers & Hubbard,	8	4	8	100.00	4	–	–
Rogers Manufacturing Company,	8	5	7	87.50	3	–	–
Ross Brothers,	1	–	1	100.00	1	–	–
N. Roy & Son,	1	–	–	–	1	–	–
Russia Cement Company,	11	7	11	100.00	4	–	–
Sanderson Fertilizer Company,	4	1	1	25.00	2	1	–
M. L. Shoemaker,	1	1	1	100.00	–	–	–
Smith Agricultural Chemical Company.	8	1	4	50.00	4	2	1
Sterling Chemical Company,	1	–	1	100.00	–	1	–

TABLE I — *Concluded.*

MANUFACTURER.	Number of Brands Analyzed.	Number with all Three Elements equal to Lowest Guaranty.	Number equal to Guaranty in Commercial Value.	Per Cent. of Brands not showing a Commercial Shortage.	Number with One Element below Lowest Guaranty.	Number with Two Elements below Lowest Guaranty.	Number with Three Elements below Lowest Guaranty.
Swift's Lowell Fertilizer Company,	14	3	12	85.71	10	1	-
Tavender Process Company,	1	1	1	100.00	-	-	-
Whitman & Pratt,	4	3	4	100.00	1	-	-
Wilcox Fertilizer Works,	6	6	6	100.00	-	-	-
A. H. Wood & Co.,	1	1	1	100.00	-	-	-

Summary of Analyses of Ground Bone, Dissolved Bone, Tankage and Dry Ground Fish, 1907.

The following table presents the same information as the previous one, with the exception of the column giving the percentage number which do not show a commercial shortage; this was omitted on account of the small number of brands of these raw materials licensed by each manufacturer.

TABLE II.

MANUFACTURER.	Number Brands Analyzed.	Number with Two Elements above Guaranty.	Number equal to Guaranty in Commercial Value.	Number with One Element below Guaranty.	Number with Two Elements below Guaranty.
W. H. Abbott,	1	1	1	-	-
American Agricultural Chemical Company,	1	-	-	1	-
Armour Fertilizer Works,	1	1	1	-	-
Beach Soap Company,	1	-	1	1	-
Bowker Fertilizer Company,	4	2	4	2	-
Buffalo Fertilizer Company,	1	-	-	-	1
John C. Dow & Co.,	1	1	1	-	-
R. & J. Farquhar & Co.,	1	-	1	1	-
Thomas Hersom & Co.,	2	2	2	-	-
Home Soap Company,	1	1	1	-	-
Geo. E. Marsh Company,	1	-	1	1	-
D. M. Moulton,	1	-	-	-	1

TABLE II — *Concluded.*

Manufacturer.	Number Brands Analyzed.	Number with Two Elements above Guaranty.	Number equal to Guaranty in Commercial Value.	Number with One Element below Guaranty.	Number with Two Elements below Guaranty.
National Fertilizer Company,	2	–	1	2	–
Olds & Whipple,	1	1	1	–	–
Parmenter & Polsey Fertilizer Company,	1	–	1	1	–
W. W. Rawson & Co.,	1	1	1	–	–
Rogers & Hubbard Company,	2	1	2	1	–
Rogers Manufacturing Company,	1	1	1	–	–
Russia Cement Company,	1	1	1	–	–
Sanderson Fertilizer and Chemical Company,	1	–	–	1	–
Springfield Rendering Company,	2	1	2	1	–
Swift's Lowell Fertilizer Company,	4	2	3	2	–
T. L. Stetson,	1	–	1	1	–
A. L. Warren,	1	1	1	–	–
Whitman & Pratt Rendering Company,	1	–	1	1	–
Wilcox Fertilizer Works,	1	1	1	–	–
Sanford Winter & Son,	1	1	1	–	–
J. M. Woodard & Bro.,	1	1	1	–	–

4. MISCELLANEOUS FERTILIZERS, SOILS AND BY-PRODUCTS FOR FREE ANALYSIS.

During the past season 208 samples of fertilizer and refuse by-products used for fertilizing purposes, 79 soils and 25 miscellaneous substances have been fowarded for analysis by farmers and others interested in agriculture. The greater part of these samples have been taken according to printed instructions forwarded from this office. It is the usual custom, when application is made for free analysis, to send the applicant the necessary directions for taking an average sample. This is of the utmost importance, for unless an average sample is furnished, a representative analysis cannot be obtained. As a general thing, these samples are analyzed in the order of their arrival. During the season of the inspection of commercial fertilizers we are not able at all times to promptly attend to the requests for the analysis of this class of materials. Samples are, however, tested as promptly as possible, and reported together with whatever information has been asked for by the applicant. Samples received during the fall and winter months can be examined more quickly, and will ordinarily be reported in a few days after they are received.

5. Execution of the Feed Law (Acts of 1903, Chapter 122).

Since July 1, Mr. P. H. Smith has been charged with carrying out the provisions of this act, and has proved his ability to handle the work to the complete satisfaction of the writer. At the beginning of the year 1907 the inspector made a complete canvass of the State, and collected 477 samples, all of which were examined during the winter and early spring months. It was not possible to publish the results in bulletin form, but the analyses of those falling substantially below the guaranty, or in which any inferior condition was noted, were reported to the manufacturer, with such comments and suggestions as the circumstances seemed to warrant.

The chief result of the inspection was the discovery of numerous lots of inferior cotton-seed meal. Because of heavy rainfalls in the autumn of 1906, large quantities of cotton-seed were considerably damaged, and as a result much of the meal was seriously off grade in color, texture and chemical composition. Of the 75 samples examined, 65 were guarantied to contain 41 or more per cent. protein; and of this number 75 per cent. fell below the guaranty, some very much more so than others. Those samples put out by Kaiser & Brown, Memphis, Tenn., bore a 41 per cent. guaranty and tested 20 to 21.50 per cent. of protein, and were unquestionably fraudulent. Of the 18 lots of Star Brand put out by the J. Lindsey Wells Company, Memphis, Tenn., only 3 met their guaranties; 8 fell nearly 5 per cent. of protein below the minimum, and 7 showed a deficit of 5 to 7 per cent.

While it was naturally beyond the power of man to control the weather conditions, it is believed that many southern brokers were decidedly lax in their method of dealing, and attached a 41 per cent. protein guaranty to whatever meal they shipped, without any particular regard to its quality.

The writer is also convinced that certain northern jobbers soon discovered that the meal they were receiving was inferior to the guarantied representations. They proposed, however, to take their chances, and, in case they were found out, plead ignorance and bad weather; and, if absolutely necessary, settle with the local dealer with the least loss to themselves. The station, by all means in its power, endeavored to keep both the dealer and consumer informed regarding the true conditions. A special circular of 8 pages was prepared and sent to every important feed dealer in the State. All samples of meal received from local dealers and private parties were examined and the results reported within two or three days.

Beginning in late August, 1907, the inspector canvassed the State, and completed his work about the middle of October, collecting 364 samples, all of which have been examined chemically and many also submitted to a microscopic analysis. Concentrated feeds have ruled exceptionally high in price, and many dealers were carrying very limited stocks, some of the ordinary brands being temporarily out of the market. Comparatively few violations of the law were noted, and these were mostly of a technical character. The results of the autumn inspection are now in press (December, 1907), and will appear in bulletin form.

Only one new feed was found during the present autumn. It is known as flax feed, and is composed substantially of one-third small and imperfectly developed flax seed and two-thirds of a variety of ground weed seeds. It has an extremely bitter taste. It has been fed to several cows in the station herd, and no objectionable taint was noted in the milk. The cows ate it rather grudgingly when fed by itself, but consumed it readily when mixed with other grains. The price asked — $26 a ton — is considered high.

6. Milk, Cream and Feeds sent for Free Examination.

Many dairymen frequently send samples of milk and cream to be tested for total solids and fat, in order to ascertain the quality of the product yielded by the cows composing their herds. The State and local boards of health, as well as the large milk contractors, keep a watchful eye over the composition and condition of the milk supply of the State, and many producers frequently receive warning that their product is deficient in one or more particulars. This induces them to send samples to the station for examination and to ask for advice. The milk is examined promptly, and the results, together with the necessary comments, are forwarded without delay. The station is always ready, to the full extent of its resources, to lend a helping hand to such as ask. One creamery sends all of its samples to the station to be tested for butter fat, and two others send a number of samples every two weeks. A charge is made in such cases, to cover the necessary expense.

Samples of feeds are constantly received from farmers, local dealers and jobbers, who wish to ascertain not only if the materials sent are as represented, but also regarding their particular feeding value. In most cases a partial chemical or microscopic analysis only is necessary to enable one to furnish the desired information. There is a constant tendency on the part of some jobbers to use the station in place of private chemists. It must be distinctly understood that, while it is the aim of the station to furnish all parties with whatever special information its equipment makes possible, its laboratory cannot be continually at the call of those engaged in private business operations.

7. Execution of the Dairy Law (Acts of 1901, Chapter 202).

This law requires the station (*a*) to test, for accuracy of graduation, all glassware used in connection with the Babcock test or any other test in determining the value of milk and cream; (*b*) to examine for competency all parties operating such tests; and (*c*) to inspect yearly all machines thus used. The station is given authority to collect, from the parties for whom the work is done, sufficient money to cover the actual expense involved.

It is believed that the law could be improved by the addition of an amendment providing a small yearly appropriation ($400), to enable the station to make semiannual inspections of machines and operators, and by giving it authority to remove all operators who employed dirty glassware and who were not conscientiously performing their duties. The result of the year's work may be summarized as follows: —

(*a*) *Testing of Glassware.* — Each piece of glassware found to be correct has the words "Mass. Ex. Sta." etched on. There were examined 3,082 pieces, of which 204, or 6.62 per cent., were condemned.

(*b*) *Examination of Candidates.* — Twenty-one candidates were examined during the year 1907. Most of those presenting themselves for examination had a fair understanding of the process, although it was frequently necessary to refuse certificates, insist on further preparation and a second examination. It is believed that the station would be false to its trust if it allowed candidates to pass who did not have a satisfactory theoretical and practical understanding of the method of procedure.

(*c*) *Inspection of Babcock Machines.* — The annual inspection of Babcock machines was made in November of 1907. Of the 36 places visited, 22 were creameries, 11 milk depots, 2 city milk inspectors and 1 a chemical laboratory. Sixteen of the creameries were co-operative and 5 were proprietary or managed by stock companies. The 11 milk depots in operation were in every case proprietary.

Thirty-seven machines were inspected, of which 2 were condemned and 1 was found needing additional heat. The machines in use are 14 Facile, 9 Agos, 6 Wizard, 5 Electrical and 2 Stoddard.

The glassware as a whole was clean, but a few still use very dirty bottles and 3 were found using untested glassware. Following is a list of creameries and milk depots now in operation that pay by the Babcock test: —

1. Creameries.

Location.	Name.	President or Manager.
1. Ashfield, ...	Ashfield Co-operative, . .	Wm. Hunter, manager.
2. Belchertown, . . .	Belchertown Co-operative, .	M. G. Ward, president.
3. Brimfield, . . .	F. N. Lawrence, . . .	F. N. Lawrence, proprietor.
4. Cheshire, ...	Greylock Co-operative, .	C. J. Fales, president.
5. Cummington, . . .	Cummington Co-operative, .	W. E. Partridge, manager.

1. Creameries — Concluded.

Location.	Name.	President or Manager.
6. Egremont,	Co-operative,	E. A. Tyrrell, manager.
7. Easthampton,	Hampton Co-operative,	W. H. Wright, superintendent.
8. Heath,	Cold Spring,	F. E. Stetson, manager.
9. Hinsdale,	Hinsdale Creamery Company.	W. C. Solomon, proprietor.
10. Lenox,	Lenox Creamery,	P. A. Agnew, manager.
11. New Salem,	New Salem Co-operative,	W. A. Moore, president.
12. Monterey,	Berkshire Co-operative,	F. A. Campbell, manager.
13. North Orange,	North Orange Co-operative,	C. E. Dunbar, manager.
14. Northfield,	Northfield Co-operative,	L. R. Smith, superintendent.
15. Shelburne,	Shelburne Co-operative Creamery.	Ira Barnard, manager.
16. Shelburne Falls,	Shelburne Falls Creamery,	T. M. Totman, proprietor.
17. Springfield,	Tait Bros.,	Tait Bros., proprietors.
18. Westfield, P. O. Wyben Springs.	Wyben Springs Co-operative,	C. H. Wolcott, manager.
19. West Newbury,	West Newbury Co-operative,	R. S. Brown, manager.
20. Williamsburg,	Williamsburg Creamery,	D. T. Clark, manager.
21. Worthington, P. O. Ringville.	Worthington Co-operative,	M. R. Bates, superintendent.

2. Milk Depots.

Location.	Name.	President or Manager.
1. Cambridge,	C. Brigham Company,	J. R. Blair, manager.
2. Cheshire,	Ormsby Farms,	E. B. Penniman, proprietor.
3. Beverly,	Cherry Hill Farm,	Henry Fielden, superintendent.
4. Dorchester,	Elm Farm Milk Company,	J. H. Knapp, manager.
5. Sheffield,	Willow Brook Dairy,	G. W. Patterson, manager.
6. Southboro,	Deerfoot Farm,	S. H. Howes, manager.
7. Boston, P. O. Charlestown.	D. W. Whiting & Sons,	George Whiting, manager.
8. Boston, P. O. Charlestown.	H. P. Hood & Sons,	Wm. Brown, manager.
9. Boston,	Boston Dairy Company,	W. A. Graustein, president.
10. Boston,	Walker-Gordon Laboratory,	Merrill B. Small, manager.
11. Boston, P. O. Roxbury,	Alden Bros.,	Alden Bros., proprietors.

8. Sanitary Analysis of Drinking Water.

The experiment station has made sanitary examinations of drinking water since its establishment in 1882. Since January, 1903, because of the abuse of the privilege of free analysis and because of the increase of other important lines of work, a charge of $3 a sample has been made. Special jars are furnished, together with full instructions for collecting and forwarding the samples. An analysis of water sent in shipper's jar will not be made, neither will bacteriological nor mineral analyses be undertaken. A sanitary analysis is made to determine whether the water is contaminated with bad drainage from privy vaults, barns or sinks. A mineral analysis is usually undertaken to ascertain the amount of the several mineral ingredients contained in the water, and thus to gain information relative to its supposed medicinal properties. Parties wishing such information are referred to private chemists.

The water examined the past year was of the usual quality. It was derived largely from springs and wells which had frequently become polluted from the ordinary sources. After the soil once becomes contaminated, it requires considerable time to purify itself, and the water is likely to be rendered unfit for use for a number of years. Too great care cannot be exercised by parties depending for their supply upon wells and springs located close to dwelling houses, barns or other buildings. Samples are sometimes found contaminated with lead. It is strongly advised that all lead pipe be removed and replaced with iron coated with asphaltum or with galvanized-iron pipe. Lead is a poison, and if it once enters the system it is very difficult to eradicate it.

9. The Testing of Pure-bred Cows.

This department continues its work in testing pure-bred cows under the rules and regulations of the Jersey, Guernsey, Holstein-Friesian and Ayrshire breeders' associations. The work for Jersey and Guernsey breeders is confined almost exclusively to consecutive monthly tests for the purpose of securing yearly records. Sixty-three cows are now in the test, which requires the services of one man nearly the entire month. Holstein breeders require, as a rule, seven-day tests, although in some cases the time limit is set at fourteen and thirty days, and in occasional instances ninety days, should the animals under test be making phenomenal records. At times between the months of December and May four or five men are thus employed.

Only one Ayrshire breeder (G. E. Stone of Littleton) is at present making a yearly test of his herd.

The station has issued a special circular, giving breeders full information relative to the making of such tests; the circular also states the rules and regulations governing the same. All records, after being verified and sworn to, are forwarded to the several cattle clubs and a duplicate copy kept on file at this office. There have been completed during the year 5 Guernsey and 30 Jersey yearly records and 70 Holstein records (53 of which were of seven days' duration, 10 for fourteen days and 7 in excess of fourteen days).

It hardly seems that it is the proper function of the experiment station to do work of this kind, but it will continue to give such matters attention until other facilities are provided for the accommodation of breeders.

10. Special Chemical Work.

The station has co-operated with the association of official agricultural chemists in studying the accuracy of methods for the determination of nitrogen and in ascertaining the most suitable methods to be used in the analysis of condensed milk. These results were reported to several referees of the association.

Mention may also be made of a study to ascertain the best methods to be employed in determining water and the several sugars in molasses, also of a determination of the fat constants of soy bean oil. These investigations will be published as a part of this report or elsewhere.

11. Work Completed.

Molasses and Molasses Feeds.

The station has made a study of the value of molasses and molasses feeds for dairy cattle, horses and swine, and has published its findings, together with the most important results secured by German and French investigators, in Bulletin No. 118, which is now ready for distribution.

The value of molasses was discussed under the following headings: composition, effect of molasses on digestibility of other feed stuffs, digestion coefficients for molasses, relative values of molasses and corn meal, and the uses of molasses as a component of the daily rations for the several important kinds of farm animals. The conclusions may be summarized briefly as follows: —

For Dairy Cattle. — No particular advantage is to be gained under ordinary conditions by the northern farmers, from the use of molasses as a food in place of corn meal and similar carbohydrates. As an appetizer for cows out of condition, to induce a temporary maximum food consumption and for facilitating the disposal of unpalatable and inferior roughage and grain, two to three pounds daily of molasses undoubtedly would prove helpful and economical.

For fattening Cattle. — Some three pounds daily may be fed advantageously, especially during the finishing process, when the appetite is likely to prove fickle. The object at such times should be to make the food especially palatable, and thus induce a maximum consumption and also to secure a bright, sleek appearance.

For Horses. — In spite of the many reports favorable to the use of molasses for horses, the writer is not inclined to recommend to northern farmers its indiscriminate use in place of the cereals and their by-products. As an appetizer and tonic for horses out of condition, as a colic preventive and for improving the palatability of rations, two to three pounds daily of molasses would undoubtedly prove productive of satisfactory results.

For Pigs. — These animals will consume reasonably large quantities of cane molasses daily without ill effects (one pound per one hundred pounds live weight). Small amounts (two to three ounces daily) must be given at first and gradually increased. Molasses must be fed with foods reasonably rich in protein. If skim milk is not available, a combination by weight of two parts bran, one part gluten feed, one part corn meal and one part molasses, or one part tankage, four parts corn meal and one part molasses, ought to prove satisfactory. It is believed that no particular advantage is to be gained by employing molasses for pig feeding other than an appetizer.

The residuum molasses from Porto Rico (blackstrap) is brought in tank steamers and offered in Boston at 14 cents a gallon of 12 pounds in barrel lots. It contains about 1,100 pounds of digestible organic matter in one ton, and as a food has about 75 per cent. of the value of corn meal. The particularly favorable effect of molasses as an appetizer, etc., naturally is not included in the above estimate of its worth; neither does its lack of protein as compared with corn meal nor the extra cost and bother of handling enter into the calculation.

The value of molasses feeds was summarized under composition, digestibility, for milk production and as compared with home-mixed grain rations.

It was shown that these feeds were composed of oat and barley residues, partly ground grain screenings and malt sprouts in many cases, one-fourth to one-third molasses, and sufficient gluten feed and cotton-seed meal to supply the protein guarantied.

The total digestible organic nutrients contained in molasses feeds are in excess of those contained in wheat bran, but noticeably below those contained in flour middlings and gluten feed. The amount of protein contained in bran, middlings and gluten feed is decidedly greater than in the average of the several molasses feeds. The latter class of feeds may be said to be only moderately digestible.

No advantage is to be gained from feeding molasses feeds in place of home mixtures of standard concentrates. Digestible protein in the former feeds is decidedly more expensive, and digestible matter can generally be purchased for less money in the home mixtures.

The fact that many of the prepared molasses feeds contain considerable quantities of unground weed seeds is a decided argument against their use. Weed seeds pass through the animal undigested, and are distributed with the manure and greatly increase the cost of subsequent cultivation.

The Digestibility of Proprietary Cattle Feeds.

A considerable number of mixtures of various by-products are offered as ready rations for dairy stock. Among these may be mentioned Buffalo creamery feed, Chapin's alfalfa meal, Biles union grains, H. O. and Quaker dairy feeds, Protena, Schumacher's stock feed, Sucrene, Green Diamond and Holstein sugar feeds. In addition to an analysis, the *degree of* *digestibility* is quite necessary in order to form an accurate opinion of the true nutritive value of a feed stuff. The station has tested the digestibility of all of the above-mentioned feeds, and intends publishing the detailed results.

The requirements of any ready ration, either mixed at home from standard by-products, or purchased in the form of a proprietary mixture, may be briefly stated as follows: —

1. It should be bulky, palatable, and free from mold and rancidity.

2. It should contain at least 16 pounds of digestible protein in 100.

3. It should contain substantially 70 pounds of digestible organic nutrients in 100, and not over 9 per cent. of total fiber.

The results of our observations and digestion studies have shown that only one proprietary feed — Biles union grains — substantially conformed to the above requirements. This feed contained 17.8 pounds of digestible protein, 66.7 pounds of digestible organic matter and 9.6 pounds of total fiber in 100 pounds. The other feeds showed from 7.5 to 16.1 pounds of digestible protein, from 52 to 62 pounds of digestible organic matter and from 10 to 18 pounds of total fiber in 100. Most of the above feeds are quite expensive as sources of digestible protein, and furnish digestible organic matter at a higher cost than it can be had in the ordinary standard by-products.

The Effect of Soy Beans minus the Oil, and of Soy Bean Oil on the Composition of Milk and Butter Fat, and on the Consistency or Body of Butter.

An experiment was in progress during the winter of 1906-07 to study the physiological effect of this legume upon milk and butter. The experiment is one of a series planned to ascertain the feeding effect of the various groups of substances — protein, carbohydrates and fat — upon milk secretion in general. The beans were shipped to a western oil mill to secure the removal of the oil, the percentage being reduced from 16 to 8. It was hoped that after the extraction the residue would not show over 3 per cent., but this result was not secured. It is intended to publish and discuss the experiment in detail at a future time. The most important results only are now mentioned : —

1. Soy bean meal, after the extraction of oil, had no effect in changing the relative proportions of the several milk ingredients, did not noticeably modify the chemical composition of the butter fat, and exerted no marked influence on the body of the butter.

2. Soy bean oil temporarily increased the percentage of fat in the milk, modified the composition of the butter fat by decreasing the saponification number, the percentage of soluble fatty acids and the percentage of volatile fatty acids; it increased the iodine number from 32 to 40, and hence the olein percentage, but did not change the melting point of the fat. The oil likewise produced a softer, more yielding butter, that would not stand up well at 70° F. and above.

12. Work in Progress.

Studies in Milk Secretion.

Two grade Holstein cows are being fed a continuous hay diet during an entire lactation period; two similar cows a hay and moderate grain diet during an entire period of lactation; two Jersey cows — a high grade and a pure bred — are also receiving a hay and moderate grain diet during a period of lactation.

The objects sought are: (*a*) the variations in the chemical composition of the milk and milk fat; (*b*) the milk fat constants; (*c*) the comparative composition of the milk fat from Holstein and Jersey cows under similar conditions of feed and care. It is also intended to observe, so far as possible, the general character of the butter resulting from the hay and from the hay and grain diet. This work will continue until the autumn of 1907.

Studies in Soil Analysis.

Samples of soils from Field A, which is divided into eleven different plots, and which has been under continuous treatment since 1889, are being submitted to a careful examination, to ascertain the chemical variations in the soil resulting from different methods of fertilization. The results thus far secured show very slight differences in the amount of the several constituents present. This work is a part of an experiment under the management of the agricultural department of the station.

Effect of Molasses on Digestibility.

It is a well-known fact that the addition of considerable quantities of starch, sugar and similar substances causes a distinct depression in the digestibility of the substances with which they are fed. By digestion depression is meant the checking of the digestion and an assimilation of the other substances. A number of experiments have been made and others are still in progress to study the influence of Porto Rico molasses on the digestibility of the other ingredients of different rations. The results thus far secured may be stated briefly: —

1. When molasses fed together with hay constituted from 10 to 15 per cent. of the total dry matter of the ration, little if any depression was noted.

2. With molasses composing some 20 per cent. of the dry matter of the hay ration, a depression of 4.5 per cent. was noted in the digestibility of the hay, the digestibility of the dry matter of the latter being 58 per cent. without the molasses, and 55.4 per cent. with the molasses.

3. Molasses and hay would not make a satisfactory combination for any kind of farm stock. A more suitable ration would consist of hay, together with one or more protein concentrates and molasses. Consequently, the effect of the molasses was tested upon a combination of hay and gluten feed. The results of six single trials, in which molasses composed from 17 to 24 per cent. of the dry matter of the ration (average 20 per cent.), show that the dry matter of the combination of hay and gluten without molasses was 72.3 per cent. digestible and 66.5 per cent. digestible when fed with the molasses, hence the molasses caused a depression of 8 per cent. in the digestibility of the hay and gluten.

Early Amber Sorghum.

This plant has again proved its usefulness as a forage crop. Observations have been continued relative to the quantity of seed to be sown broadcast to the acre. Last season as satisfactory results were secured from 60 pounds as from 100 pounds of seed to the acre. The present season three 20-acre plots were each fertilized alike as heretofore and on June 11 the seed was sown broadcast at the rate of 50, 40 and 30 pounds to the acre. In spite of the late seeding and dry August, the crop grew fairly well, and when cut, September 12, was just beginning to head out. The yields, on the basis of one acre, were as follows: —

Seed per Acre.

	50 Pounds Seed to the Acre.		40 Pounds Seed to the Acre.		30 Pounds Seed to the Acre.	
	Green (Pounds).	Dry Matter (Pounds).	Green (Pounds).	Dry Matter (Pounds).	Green (Pounds).	Dry Matter (Pounds).
Plot 1, ...	32,000	6,944.0	-	-	-	-
Plot 2, ...	-	-	29,400	6,556.2	-	-
Plot 3, ...	-	-	-	-	28,800	6,278.4

The yields were not as heavy as were obtained the year previous (20,000 pounds to the acre), owing to the cool, dry August, which did not permit as advanced a development of the crop. From two years' observations it may be concluded that 50 to 60 pounds of seed to the acre are sufficient when sown broadcast for forage purposes. More than this is not necessary; smaller amounts permit a too coarse development of the individual plants, and also gives opportunity for the growth of weeds, especially during the early life of the sorghum plants.

Alfalfa in Massachusetts.

Observations have been continued relative to the suitability of alfalfa as a forage crop in this State. Last year three cuttings were secured from a one-sixth acre plot, equivalent to 3.65 tons of dry hay to the acre (basis of 15 per cent. moisture). The two small plots referred to in the previous report have been combined in one plot one-third of an acre in area. A growth of some 6 to 8 inches was allowed to remain during the autumn of 1906, to serve as a mulch. The plants came through the winter of 1906–07 in excellent condition, and started well in the spring, although the season was some ten days to two weeks late.

The first cutting contained considerable grass in spots, but yielded at the rate of 2.35 tons to the acre. Unfortunately, through an oversight, the weight of the second cutting (made in early August) was not taken. The third cutting (made September 19) stood about 2 feet high and yielded at the rate of 1 ton to the acre. The weather was very bad during the curing of this cutting, the hay standing in cocks under hay caps for two weeks, being shaken out once during that time. In spite of the bad weather condition, it was fairly well cured and the animals ate it readily. The entire yield for the season, on the basis of 15 per cent. water, must have been at the rate of nearly 4½ tons to the acre. In view of the results thus far secured, the writer is inclined to advise farmers to try alfalfa in a small way, to study its peculiarities carefully, and not to be discouraged if success is not attained at the first trial.

Cost of Rearing Dairy Stock.

The station raises one or two dairy calves yearly to keep up its herd which is being used for experiment purposes. An account has been kept of the food cost involved, and, while the data is not sufficiently complete for publication, it may be said that from $40 to $45 represents the cost of food consumed, when figured at market prices, until the animal reaches two years of age. The animals have been pastured during the summer and for the remainder of the year fed on first and second cut hay, some silage and not over two or possibly three pounds of grain daily. The grain ration has usually consisted of a mixture of bran and fine middlings.

Part II. Dairy and Chemical Studies.

1. The Chemical Composition of Milk.

J. B. LINDSEY.

The larger part of milk consists of water, which contains a variety of substances in suspension and solution. The substances largely dissolved in the water are casein and albumen, milk sugar and the ash or mineral matter, which together form the milk serum.[1] The fat is suspended in the milk in microscopic globules, which are semisolid, and with the serum form what is termed an emulsion.

The multitudinous analyses of milk have shown it to vary widely in composition, depending upon the breed and individuality of the cow, stage of lactation and weather conditions. Food, as a rule, has little effect in permanently changing the proportions of the several ingredients. Numerous authorities state that 100 pounds of milk of average quality should contain the following amounts of the different ingredients: —

		Pounds in 100, or Percentage.
Water,		87.00
Fat,		4.00
Albuminoids	Casein,	3.00
	Albumen,	.50
Milk sugar,		4.80
Ash,		.70
		100.00

The term "total solids" is meant to include all of the ingredients excepting water. For ordinary purposes the chem-

[1] That portion of the casein which can be removed by filtration through filter paper is not generally included in normal serum.

ist determines only the total solids and fat, and obtains the solids not fat by difference. The former two serve as an index of the chemical composition of the milk.

Composition of Milk of Pure-bred Cows.

The following data have been tabulated from authentic sources, in the hope that they will throw light on the composition of milk produced by distinct breeds of dairy cows : —

(*a*) American Data.

1. Jerseys.

No. of Cows.	Length of Period.	Authority.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
25	3 months, .	Chicago Exposition,[1] . .	14.00	4.78	9.28
5	6 months, .	Pan-American Exposition at Buffalo.[2]	13.90	4.58	9.32
25	4 months, .	Louisiana Purchase Exposition, St. Louis.[1]	13.50	4.70	8.80
3	One lactation period.	New York Experiment Station.[3]	15.40	5.61	9.80
3	8 months, .	New Jersey Experiment Station.[4]	14.34	4.78	9.56
		Average, 61 cows, . .	13.87	4.77	9.12

2. Guernsey.

No. of Cows.	Length of Period.	Authority.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
25	3 months, .	Chicago Exposition,[5] . .	13.78	4.61	9.17
25	6 months, .	Pan-American Exposition at Buffalo.[2]	13.90	4.60	9.30
2	One lactation period.	New York Experiment Station.[3]	14.60	5.12	9.47
3	8 months, .	New Jersey Experiment Station.[4]	14.48	5.02	9.46
2	Probably 7 days.	Wisconsin Experiment Station.[6]	14.46	5.39	9.07
		Average, 57 cows, . .	13.92	4.67	9.25

3. Holsteins.

No. of Cows.	Length of Period.	Authority.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
5	6 months, .	Pan-American Exposition at Buffalo.[2]	12.00	3.25	8.75
15	4 months, .	Louisiana Purchase Exposition, St. Louis.[1]	11.30	3.40	7.90
70	Generally 7 days.	Wisconsin Experiment Station.[6]	11.78	3.33	8.45
1	One lactation period.	New York Experiment Station.[3]	12.39	3.46	9.07
3	Eight months,	New Jersey Experiment Station.[4]	12.12	3.51	8.61
		Average, 94 cows, . .	11.73	3.34	8.39

[1] The Dairy Cow Demonstration, published by American Jersey Cattle Club, 1905, pp. 65 and 71. See also Hoard's Dairyman, Nov. 24, 1893, p. 638. This paper gives 13.71 as the total solids for Jerseys.

[2] DeWitt Goodrich, Official Milk Tester (in Creamery Patrons' Handbook, p. 166).

[3] Tenth report, p. 141.

[4] Report for 1890, p. 223.

[5] Furnished by W. H. Caldwell, secretary, American Guernsey Cattle Club. Hoard's Dairyman gives 13.41 per cent. solids and 4.51 per cent. fat for Guernseys.

[6] Twentieth report, p. 158.

4. *Ayrshires.*

No. of Cows.	Length of Period.	Authority.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
5	6 months, .	Pan-American Exposition, Buffalo.[1]	12.60	3.60	9.00
4	One lactation period.	New York Experiment Station.[2]	13.06	3.57	9.35
3	Eight months,	New Jersey Experiment Station.[3]	12.70	3.68	9.02
		Average, 12 cows, . .	12.78	3.61	9.12

5. *Shorthorns.*

No. of Cows.	Length of Period.	Authority.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
24	3 months, .	Chicago Exposition,[4] . .	12.41	3.64	8.77
5	6 months, .	Pan-American Exposition, Buffalo.[1]	12.80	3.57	9.23
25	4 months, .	Louisiana Purchase Exposition, St. Louis.[4]	12.20	3.60	8.60
2	Probably 7 days.	Wisconsin Experiment Station.[5]	12.60	3.52	9.08
		Average, 56 cows, . .	12.36	3.61	8.75

6. *Brown Swiss.*

No. of Cows.	Length of Period.	Authority.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
5	6 months, .	Pan-American Exposition, Buffalo.[1]	12.70	3.63	9.07
5	4 months, .	Louisiana Purchase Exposition, St. Louis.[4]	12.50	3.60	8.90
		Average, 10 cows, . .	12.60	3.62	8.98

7. *Devons.*

No. of Cows.	Length of Period.	Authority.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
2	One lactation period.	New York Experiment Station.[2]	13.77	4.15	9.60

Summary American Data.

Breed.	Number of Cows.	Total Solids (Per Cent.).	Butter Fat (Per Cent.).	Solids not Fat (Per Cent.).
Jerseys, ...	61	13.87	4.77	9.12
Guernseys, ...	57	13.92	4.67	9.25
Holsteins, ...	94	11.73	3.34	8.39
Ayrshires, ...	12	12.78	3.61	9.12
Shorthorns, ...	56	12.36	3.61	8.75
Brown Swiss, ...	10	12.60	3.62	8.98
Devons, ...	2	13.77	4.15	9.60

[1] DeWitt Goodrich, Official Milk Tester (in Creamery Patrons' Handbook, p. 166).

[2] Tenth report, p. 141.

[3] Report for 1890, p. 223.

[4] The Dairy Cow Demonstration, published by American Jersey Cattle Club, 1905, pp. 65 and 71. See also Hoard's Dairyman, Nov. 24, 1893, p. 638.

[5] Twentieth report, p. 158.

In addition to the above, F. W. Woll[1] gives the following: —

Summary of American Analyses for Butter Fat in Milk of Pure-bred Cows.

Breed.	No. of Cows.	Butter Fat (Per Cent.).
Jerseys,	491	4.98
Guernseys,	191	4.77
Holsteins,	679	3.28
Ayrshires,	108	3.84
Shorthorns,	370	3.73
Brown Swiss,	20	3.78
Devons,	50	4.57

(*b*) Foreign Data.

According to Hucho[2] and Koenig,[2] German authorities, the average composition of the milk of different breeds is as follows: —

Breed.	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
Holsteins,[3]	12.00	3.25	8.75
Ayrshires,	12.50	3.70	8.80
Shorthorns,	12.90	3.80	9.10
Devons,[3]	13.40	4.40	9.00
Jerseys,	14.70	5.00	9.70
Guernseys,	14.70	5.00	9.70

The average breed tests, conducted at the annual dairy shows of the British Dairy Farmers Associations, 1879–98 inclusive, have given the following results: [4] —

Breed.	Number of Cows	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).
Jerseys,	272	14.46	4.98	9.48
Guernseys,	98	13.50	4.61	8.89
Holsteins,	10	12.25	3.41	8.84
Ayrshires,	42	13.29	4.19	9.10
Shorthorns,	236	12.72	3.75	8.97
Devons,	2	14.34	4.90	9.44

[1] Twentieth report, p. 158.
[2] Hatch Experiment Station, Bulletin No. 110, pp. 6 and 7. See also Woll's Handbook, first edition, p. 213.
[3] Koenig, Die Menschlichen Nährungs- und Genussmittel.
[4] Woll's Handbook, fourth edition, 1907, p. 241.

COMPOSITION OF MIXED MILK (LARGELY GRADE COWS, ALL BREEDS).

American and Foreign.

Number Analyses.	AUTHORITY.	Total Solids (Per Cent.).	Butter Fat (Per Cent.).	Solids not Fat (Per Cent.).
793[1]	Koenig,[2]	12.88	3.69	9.19
200,000	Aylesbury Dairy Company, London,[3] .	12.90	3.90	9.00
4,103	Hatch Experiment Station,[4] . . .	13.63	4.43	9.20
110	Hatch Experiment Station,[5] . . .	13.23	4.49	8.74
5,552	Van Slyke,[6]	12.70	3.90	8.80

Naturally, the larger the proportion of cows in a given area producing thin milk, the nearer will the mixed milk in that area approach 12 per cent. solids ; and the larger the proportion of cows in a given area producing thick or rich milk, the nearer will the average of the mixed milk be to 13 per cent. or more of solids.

1 Number of cows.
2 Koenig, Die Menschlichen Nährungs- und Genussmittel.
3 Dairy Chemistry, Richmond, p. 120.
4 Eighteenth report, p. 223.
5 Bulletin No. 110 (Amherst and Northampton Milk Supply).
6 Modern Methods of Testing Milk, p. 15.

2. The Effect of Food upon the Composition of Milk and Butter Fat, and upon the Consistency or Body of Butter.

J. B. LINDSEY.

The writer, together with a number of co-workers, from time to time has conducted a number of long-continued experiments relative to the effect of food and food constituents upon milk, butter fat and butter. Work of this sort is still in progress. The most important results thus far secured may be briefly enumerated below. The full data of the soy bean experiment have not been published.

(a) *Effect on the Milk.*

1. Different amounts of *protein* in the daily ration derived from linseed, cotton-seed, soy bean and corn gluten meals, do not seem to have any pronounced effect in changing the relative proportions of the several milk ingredients.

2. *Linseed oil* in flaxseed meal, when fed in considerable quantities (1.40 pounds digestible oil daily), increased the fat percentage from 5 to 5.56, and slightly decreased the nitrogenous matter of the milk. This fat increase was only temporary, the milk gradually returning (in four or five weeks) to its normal fat content. The nitrogenous matter also gradually returned to normal, but more slowly than did the fat.

3. Three pounds of *cotton-seed meal* with minimum oil (8 per cent.), when fed daily to each animal, had no noticeable influence on the composition of the milk.

4. The addition of ½ to ¾ of a pound of *cotton-seed oil* to the cotton-seed meal ration appeared to increase the fat percentage of the milk about .4 of 1 per cent. (5 to 5.4), and this increase was maintained during the six weeks of the feeding period.

5. The substitution of *linseed meal* with a minimum percentage of oil (3 per cent.) in place of the cotton-seed meal and cotton-seed oil resulted in a decline of the fat in the milk to its normal percentage. This change probably was due to the removal of the cotton-seed oil from the ration, and not to the influence of the linseed meal.

6. The addition of .6 of a pound of *corn oil* to a ration made up of a mixture of grains low in fat increased the fat percentage of the milk .23 per cent. (5.17 to 5.40). At the end of two weeks the effect of the corn oil had disappeared, and the milk had returned to its normal fat content.

7. The sudden removal of the *corn oil* from the daily ration caused a drop of .54 per cent. in the fat (4.97 to 4.43), but after the first week the normal fat per cent. was again present.

8. *Corn oil* appeared to have depressed the nitrogen percentage of the milk by .034 per cent. (.610 to .576), the nitrogen gradually returned to its normal percentage after the feeding of the corn oil had ceased.

9. *Corn meal* (a carbohydrate feed) was without effect on the composition of the milk.

10. Two to 3 pounds of *soy bean meal* with a minimum oil percentage (8 per cent.), fed daily to each animal, did not appear to in any way modify the proportions of the several milk constituents.

11. The addition of ½ to 1 pound daily of *soy bean oil* to a basal ration of grain and hay very slightly increased the fat percentage in the milk during the first two or three weeks (.10 per cent.). No other variation was noted.

12. The sudden removal of the *soy bean oil* from the ration caused a drop of .25 per cent. of the fat percentage of the milk. At the end of three weeks the milk had not regained its normal fat percentage.

(*b*) *Effect on Butter Fat.*

13. *Corn gluten* and *linseed meals* with a minimum percentage of oil (3 per cent.) produced a normal butter fat. *Cotton-seed and soy bean meals* with a minimum oil percentage (8 per cent.) likewise effected little change in the composition of the butter fat. *Corn meal* was without noticeable influence on the composition of the butter fat.

14. *Linseed oil* (1.4 pounds digestible oil per head daily)

produced a noticeable change in the composition of the butter fat, causing a decrease in the volatile acids and an increase in the melting point and olein percentage (soft fat).

15. *Cotton-seed oil* (.5 pound daily per head) increased the melting point and the olein percentage of the butter fat.

16. *Corn oil* (.6 pound per head daily) decreased the volatile fats and increased the percentage of olein; the melting point of the fat remained unchanged.

17. *Soy bean oil* (.50 to 1 pound daily per head) caused a drop in the saponification number of some 10 points, a decrease in the soluble fatty acids and in the volatile fatty acids (Reichart-Meissl number), an increase in the iodine number (percentage of olein) from 32 to 40, while little or no change was noted in the melting point of the butter fat.

18. A rise in the iodine number (increase of olein) is a reasonably sure indication of a soft-bodied butter which will lack in firmness at a temperature of 70° F. An increase in the melting point of the butter fat is not a sure indication of a harder, firmer butter. It seems evident that the proportions of the several fats is more or less changed by an excess of oil in the feed and that this change of proportions varies the melting point in the fat in some such way as the melting point of a mixture of metals is changed by the resulting amalgamation.

(c) *Effect on Butter.*

19. The effect of *linseed meal* with a minimum percentage of oil (3 per cent.) on the general character of the butter was not positively identified.

20. *Cotton-seed meal* with a relatively high oil percentage (12.6 per cent.) produced butter that was rather crumbly when hard, and slightly salvy to the taste. Cotton-seed meal with a minimum percentage of oil (8 per cent.) likewise produced a hard, firm butter.

21. *Corn gluten meal* with a minimum percentage of oil (2 to 3 per cent.) produced a rather soft, yielding butter.

22. *Soy bean meal* with minimum oil (8 per cent.) produced butter that was rather softer and more yielding to the touch than that derived from a grain ration composed entirely of bran, ground corn and oats, gluten feed and cotton-seed meal.

23. An excess of *linseed oil* (1.4 pounds digestible oil per head daily) produced a very soft, salvy butter, with an inferior flavor.

24. The addition of *cotton-seed oil* (.5 pound per head daily) to a normal ration, or to one containing 3 pounds of cotton-seed meal low in oil, produced a softer, more yielding butter than that produced by the ration with the oil omitted.

25. The addition of *corn oil* (.6 pound daily per head) to a normal ration containing 2 pounds of corn gluten meal low in oil produced a noticeably softer butter than when the oil was omitted.

26. *Corn meal* tended to produce a reasonably hard, firm butter, of an agreeable flavor.

27. *Soy bean oil* (.5 to 1 pound daily per head) added to a grain ration produced a butter that was noticeably soft and yielding to the touch, and that would not stand up well at 70° F. and above.

The experiments thus far completed enable one to draw the following general conclusions : —

1. Neither the *proteid* nor the *carbohydrate groups*, when fed in normal amount, have any noticeable influence in changing the proportions of the several milk ingredients, nor in modifying to any marked degree the character of the butter fat as revealed by the ordinary chemical tests; such changes, so far as they are the result of food, are due to the presence of oil in the feed stuff.

2. Some proteids produce a harder, firmer butter than others, while the tendency of starchy foods is to produce a firm-bodied butter. *Vegetable oils* in excess of the normal amount produce a noticeably soft-bodied butter.

3. It is not considered advisable to feed large quantities of oil to cows, it having a tendency to derange the digestive and milk-secreting organs.

4. The flavor of butter depends primarily on the cleanliness of the milk, stage of lactation of the animal, skill and care of the butter maker, and especially upon the character of the starter employed. Normal feed stuffs must be considered of secondary importance in establishing butter flavor.

3. Standard for Babcock Glassware.

E. B. HOLLAND, M.S.

The Massachusetts Legislature, in the spring of 1901, enacted a measure entitled "An Act to provide for the protection of dairymen,"[1] which took effect the first of July of that year. This dairy law, so called, required, among other things, that Babcock glassware should be tested for accuracy, and made it the duty of the director of the experiment station or his agent.[2] The statute designated no standards whatsoever, leaving the matter entirely to the discretion of the experiment station. After visiting several stations and consulting the official having charge of such work, a standard, methods of testing and an allowable limit of error, conforming in general to the requirements of other New England States, were adopted provisionally and published in the fourteenth and fifteenth annual reports of this station.[3]

Up to the end of the last fiscal year (Dec. 1, 1907), 18,855 pieces of glassware had been tested, of which 1,770 pieces, or 9.39 per cent., were condemned. The yearly totals recorded below show marked variations, but with a high average percentage of inaccuracy.

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[1] Acts and Resolves of Massachusetts for 1901, chapter 202, sections 1-7, Revised Laws of Massachusetts for 1902, chapter 56, sections 65-69.

[2] Sections 1, 2.

[3] Hatch Experiment Station, annual reports for 1901 and 1902.

Amount of Glassware tested.

Year.	Total Number of Pieces.	Number Inaccurate.	Per Cent. Inaccurate.
1901,	5,041	291	5.77
1902,	2,344	56	2.39
1903,	2,240	59	2.63
1904,	2,026	200	9.87
1905,	1,665	197	11.83
1906,	2,457	763	31.05
1907,	3,082	204	6.62
Totals,	18,855	1,770	9.39[1]

The grand totals may be further subdivided into the several classes of glassware of which they were composed: —

Character of Glassware tested.

Kind.	Total Number.	Number Inaccurate.	Per Cent. Inaccurate.
Cream bottles,	7,714	710	9.20
Milk bottles,	6,826	784	11.49
Skim milk bottles,	675	106	15.70
Pipettes,	2,834	69	2.43
Acid measures,	806	101	12.53
Totals,	18,855	1,770	9.39[1]

The manufacturers repeatedly protested against the refusal of their glassware, and asserted that similar shipments were passed in other States. Such might easily have been the case, where the error was small, due to differences in method of testing or in allowable limit of error, possibly both. In some instances the condemned pieces were forwarded to another station and retested, but even this apparently failed to satisfy the manufacturers. It became evident that further investigation was necessary in order to bring the matter to an unquestionable basis and to remove all reasonable grounds for complaint.

[1] Average.

Original Standard.

Dr. Babcock,[1] originator of the method, laid down the following requirements relative to the graduation of bottles: —

> The 10 per cent. of fat represented upon the necks of the bottles correspond to a volume of 2 cubic centimeters.

In addition, this is stated to be equivalent by weight to 2 grams of water or 27.18 grams of mercury (specific gravity 13.59). No mention of temperature being made, presumably 60° F. was intended. This would indicate the Mohr cubic centimeter, and is supported by a statement of the Emil Greiner Company, under date of Dec. 3, 1906: —

> When we made the first bottles for Dr. Babcock, nearly twenty years ago, we were simply told to graduate the space of 2 cubic centimeters into 50 parts, and each five parts representing 1 per cent. butter fat. Therefore, 1 per cent. is .2 of a cubic centimeter, and at that time the Mohr cubic centimeter was considered the standard.

Concerning the graduation of pipettes, Dr. Babcock stated: —

> It should contain, when filled to the mark, 17.6 cubic centimeters . . . (and) . . . will deliver a little less than 17.5 cubic centimeters of milk.

Capacity in Mohr cubic centimeters was evidently the intent of the graduation.

Manufacturers' Basis of Graduation.

The eastern trade in Babcock glassware is largely supplied by three manufacturers, the Emil Greiner Company of New York, Kimball Glass Company of Chicago and Wagner Glass Works of New York. Upon request, the above firms furnished the following data relative to their standards of graduation. The Emil Greiner Company employed the Mohr cubic centimeter (1 gram of water at 15° C.), and calibrated with either water or mercury (specific gravity 13.6 at ordinary room temperature). The Kimball Glass Company used the true cubic centimeter, and calibrated with mercury (specific gravity

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[1] Wisconsin Agricultural Experiment Station, seventh (1890), ninth (1892) and tenth (1893) annual reports.

13.5463 at 20° C.). The Wagner Glass Works reported 1 cubic centimeter as equal to 13.59 grams of mercury at 60° F., which was probably the Mohr cubic centimeter.

The differences were not large or the errors especially serious, but the need of a scientific standard was unmistakable, if uniformity was to be secured with a safe interchange of apparatus. Only the *limit* of error has permitted the interchange of apparatus in the past, which is a point to be noted.

Reasons for a New Standard.

With these facts at hand, it was necessary to submit the case to some recognized authority for a decision, or at least advice as to what action ought to be taken. This plan also seemed the most promising for the reason that the two parties interested, the manufacturers[1] and the State officials,[2] neither agreed with each other nor among themselves as to a standard or methods of testing. The matter was finally referred to the National Bureau of Standards at Washington, as the body best fitted to deal with the case. Director Stratton[3] wrote as follows: —

> We are decidedly of the opinion that there would be less likelihood of errors in milk-testing work if all volumes were expressed in true cubic centimeters. It of course does not make any difference what unit is used, provided the same one is used to measure the milk sample and the fat; but if — as might easily happen — the pipettes used to measure the milk are graduated on one basis and the neck of the flask on another basis, serious errors might be introduced in the result.
>
> Referring again to the question of graduating Babcock ware for testing milk, which we have given some attention, we hope that you will see your way clear to adopt as the unit in this work the true cubic centimeter at 20° C. This, we feel confident, will prevent confusion in the end, by bringing the apparatus used in testing milk and other dairy products in agreement with the volumetric apparatus used by chemists in general. While the practice of using the gram of water at a certain temperature may have possessed some advantages in Mohr's days, we doubt very much whether it would be any convenience to use such units as the gram of water at 15°, 17.5° or 20° at the present time.
>
> The use of the true cubic centimeter is necessary in all absolute work, and it cannot under any circumstances be dispensed with.

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[1] *Loco citato.* [2] Station reports and correspondence. [3] Correspondence.

New Standard.

The recommendation by the Bureau of the true cubic centimeter as the basis of graduation, because it is a well-defined unit, universally recognized, and for uniformity in volumetric apparatus, appeared worthy of acceptance. The standard or basis of graduation was eventually drafted as follows: —

SECTION 1. The unit of graduation for all Babcock glassware shall be the true cubic centimeter (0.998877 grams of water at 4° C.).

(*a*) With bottles, the capacity of each per cent. on the scale shall be two tenths (0.20) cubic centimeter.

(*b*) With pipettes and acid measures, the delivery shall be the intent of the graduation and the graduation shall be read with the bottom of the meniscus in line with the mark.

As the necessary change in graduation is slight and the manufacturers few in number, there appear no serious obstacles in the way of the adoption of the new standard, though one firm opposed it as impracticable.

Methods of Testing.

(*a*) *Babcock Bottles.* — Of the several methods[1] in vogue for testing Babcock bottles, calibration with a weighed amount of mercury was the most sensitive, because of the high specific gravity of the metal. The process had also the advantage of being generally understood and extremely simple. The figures assumed for the specific gravity of mercury, however, have usually been too high. According to the Bureau of Standards,[2] 1 cubic centimeter at 20° C. should weigh in air against brass weights 13.5471 grams. The official method was readily deduced from the above.

SECTION 2. The official method for testing Babcock bottles shall be calibration with mercury (13.5471 grams of clean, dry mercury at 20° C., carefully weighed on analytical balances, to be equal to 5 per cent. on the scale), the bottle being previously filled to zero with mercury.

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[1] Connecticut Agricultural Experiment Station, twenty-fifth (1901) annual report, pp. 280, 281; Vermont Agricultural Experiment Station, fourteenth (1901) annual report, pp. 222, 223; Wisconsin Agricultural Experiment Station, ninth (1892) annual report, pp. 221, 222; tenth (1893) annual report, p. 125; Testing Milk and its Products, fifteenth edition, Farrington & Woll, pp. 47-53; Modern Methods of Testing Milk and Milk Products, L. L. Van Slyke, pp. 45-49.

[2] Correspondence.

The provision as to clean, dry mercury weighed on analytical balances should be carefully observed. The scale equivalent in mercury of the ordinary bottles is stated below, and that of any other percentage can be readily calculated : —

KIND.	Capacity, in Per Cent.	Grams of Mercury at 20° C.
Cream bottles, ...	50.00	135.4710
Cream bottles, ...	30.00	81.2826
Milk bottles, ...	10.00	27.0942
Skim milk bottles, ...	.50	1.3547

A number of quick methods, that are reasonably sensitive, are employed to cull out the questionable bottles. For such a purpose they are extremely valuable, but they should never be considered official. This idea was incorporated into a section.

SECTION 3. Optional methods. The mercury and cork, alcohol and burette, and alcohol and brass plunger methods may be employed for the rapid testing of Babcock bottles, but the accuracy of all questionable bottles shall be determined by the official method.

(*b*) *Pipettes and Acid Measures.* — With Babcock pipettes and acid measures, as with other volumetric apparatus of similar character, the *delivery* is, or should be, the intent of the graduation. There has been considerable discussion on this point, but the recognized practice should not be set aside and an exception made in this case. Relative to pipettes, Director Stratton [1] wrote as follows : —

The basis of test is the actual volume of water *delivered* by the pipette when used in the manner specified under Regulations for Testing.[2]

He also went on to say that, while he could not state in absolute terms the accuracy of such pipettes when used for milk, in his opinion the error would not exceed .1 cubic centimeter. In other words, a 17.6 cubic centimeter pipette would deliver in milk approximately 17.5 cubic centimeters, — what has usually been assumed. Probably this difference with milk is largely due to viscosity, though other factors enter in. Calibra-

[1] Correspondence. [2] Circular No. 9, third edition.

tion with mercury is not permissible, as it involves many points of uncertain value, and all tests[1] based on *capacity* should be excluded.

SECTION 4. The official method for testing pipettes and acid measures shall be calibration by measuring in a burette the quantity of water (at 20° C.) delivered.

Limit of Error.

The demand of State officials as to accuracy and the claims of manufactures as to their ability to graduate within definite limits agreed very closely, consequently there was little difficulty in presenting figures acceptable to both parties.

SECTION 5. The limit of error.

(*a*) For Babcock bottles, it shall be the smallest graduation on the scale, but in no case shall it exceed five tenths (0.5) per cent., or for skim milk bottles one hundredth (0.01) per cent.

(*b*) For full quantity pipettes, it shall not exceed one tenth (0.1) cubic centimeter, and for fractional pipettes five hundredths (0.05) cubic centimeter.

(*c*) For acid measures, it shall not exceed two tenths (0.2) cubic centimeter.

The new standard was submitted to Dr. Babcock, and passed without criticism. It was also sent to Professor Woll, referee on dairy products for the association of official agricultural chemists, to be presented at the 1907 meeting, but by some oversight was not forwarded to the secretary. It will be offered at the next annual meeting.

It is desired to acknowledge the valuable assistance of the manufacturers, Director Stratton and station officials, for without their co-operation the proposed standard would not have been deduced.

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[1] Connecticut Agricultural Experiment Station, twenty-fifth (1901) annual report, p. 281; Wisconsin Agricultural Experiment Station, ninth (1892) annual report, pp. 222, 223, tenth (1893) annual report, p. 126; Testing Milk and its Products, fifteenth edition, Farrington & Woll, pp. 53, 54; Modern Methods of Testing Milk and Milk Products, L. L. Van Slyke, p. 49.

REPORT OF THE BOTANISTS.

G. E. STONE, BOTANIST; G. H. CHAPMAN, ASSISTANT.

1. Outline of the year's work.
2. Seed work.
3. Seasonal peculiarities.
4. Premature defoliation of trees.
5. Asparagus rust.
6. Asparagus fusarium.
7. Peony troubles.
8. Potato diseases.
9. Experiments with fungicides.
10. Influence of potash salts on potato scab.
11. Investigations relating to mosaic disease.
12. Some factors which underlie susceptibility and immunity to disease.

1. Outline of the Year's Work.

G. E. STONE.

During the past year attention has been given to the following lines of work: correspondence; observations on and investigations of various diseases; seed separation; seed germination and seed purity testing; mechanical analyses of soils; the study of mosaic troubles of tobacco and other crops; the testing of banding substances for trees; investigations of tomato rot; experiments with the spraying of potatoes; the study of the effects of temperatures, moisture, light, etc., on greenhouse crops; and a study of the meteorological conditions affecting plant diseases and the development of crops.

Mr. N. F. Monahan, who has been connected with the department since his graduation in 1903, resigned to take up practical greenhouse and market-garden work, and his place has since been filled by Mr. G. H. Chapman of the class of 1907.

From the pathologist's standpoint every season possesses distinct individuality, and the past season has been no exception in this respect. Since the meteorological conditions are never identical in any two seasons, plant diseases show considerable variation; and, while an exceptionally dry summer like the past may be conducive to the favorable development of some crops, it is also the means of checking that of others by favoring certain plant diseases. The long period of drought was especially severe for lawns, trees and shrubs, the effect being much more pronounced in the eastern than in the western part of the State.

During the year the department has changed its headquarters from the east experiment station to Clark Hall, a new building located on the college grounds, and its equipment has been enlarged to meet the increased demand of certain lines of work.

We have been obliged to sacrifice much valuable time from experiment work, owing to the difficulty experienced in moving and setting up equipment, and it has been necessary to omit certain lines of investigation from this report.

2. Seed Work.

Work has increased in this line to some extent during the past year, 359 samples of seeds having been tested and separated in 1907, as compared with 231 in 1906. During the year many improvements have been made in the appliances used for separating seed. A Bishop & Babcock blower has been installed for the separation of tobacco seed, and altogether much attention has been given to the development of improved apparatus for this work, which has resulted in the production of an exceptionally efficient method. Arrangements have also been made for separating onion seed by electric power. Constantly increasing interest is being shown in seed testing and seed separation, and in this State as well as others considerable interest has been aroused in making people realize the necessity for pure seed.

The following tables give in brief the seed work done in 1907: —

Table I. — *Records of Seed Germination, 1907.*

Kind of Seed.	Number of Samples.	Germination.		
		Average Per Cent.	Highest Per Cent.	Lowest Per Cent.
Onion,	40	86	98.5	57
Tobacco,	2	91	92	90
Corn,	9	63	100	-
Timothy,	4	98	100	96
Celery,	3	83	91	70
Miscellaneous,	189	44	100	-
Total,	247	-	-	-

Table II. — *Records of Seed Separation, 1907.*

Kind of Seed.	Number of Samples.	Weight in Pounds.	Per Cent. of Good Seed.	Per Cent. of Discarded Seed.
Onion,	27	425	87.4	12.6
Tobacco,	85	47	84.5	15.5
Total,	112	-	-	-

The average germination of onion seed for 1907 was 86 per cent., and that of the preceding year 79 per cent., showing a better grade of seed for 1907 than 1906, so far as its germinating capacity is concerned. Some of the corn sent in did not germinate with repeated tests, which was apparently due to the immaturity of the seed.

The miscellaneous seeds in this list consist largely of flower and vegetable seeds. Some white pine seeds were tested, the per cent. of germination being 59, while frequently white pine seeds do not give more than 33 per cent. of germination.

Only 4 per cent. was discarded from the best tobacco seed by the process of air separation, while from the poorest sample 33 per cent. was discarded. At the present time most tobacco men grow their own seed, selecting carefully those plants representing the best types of tobacco; consequently, the seeds which are sent to us contain considerable chaff, which is blown out and included in the percentage of discarded seed. By this process of selection a more uniform type of tobacco is obtained and improvements in the crop rendered possible.

In the case of the best onion seed 1.6 per cent. was discarded by the use of the winnowing machine and 43.3 per cent. from the poorest sample.

The separation of tobacco and onion seed is quite generally acknowledged to be a wise course, and it is being practised extensively among growers in the Connecticut valley. In our opinion, this discarding of the inferior seed should be given more attention.

Seed to be tested or separated should be sent by either mail or express to G. E. Stone, Massachusetts Agricultural Experiment Station, Amherst, Mass. The work is done gratuitously by the station for people living in the State, but the postage or express charges should be paid by the person sending the samples.

3. Seasonal Peculiarities.

The extreme conditions which have prevailed during the past four years have been the cause of much injury to vegetation. In previous reports attention has been called to some of these troubles, more particularly to the extensive winter-killing which caused so much injury during the winter of 1903–04, at which time thousands of trees and shrubs were severely affected, many having been dying slowly ever since. Besides the trees which are dying, there are many others which are in a very weakened condition. Numerous oaks which were injured four years ago have died during the past two years, and some of those not yet dead are gradually becoming weaker. These trees are more noticeable in the eastern part of the State, and our attention has repeatedly been called to the serious condition of the elms, due to the same cause. Some very large specimens of this tree have died, and others are in poor condition.

Mention has previously been made in our reports of the condition of the red maples, many of which are now gradually dying, and the white and rock maples are suffering to a limited extent from the same cause. During the past spring some damage was done to the foliage of these trees by the late frosts.

The condition of the white pine roots has already been referred to a number of times in previous reports. Examinations of these have for the past four years been repeatedly made in various parts of the State, and it has been found that the injury to the fibrous roots is largely responsible for the poor condition of the foliage ; but the present condition of the pine roots is much more alarming, since during the past year in a very large number of cases the small feeding roots have collapsed. This is true not only of those trees which show injury from sun scorch, but of those which appear to be perfectly healthy.

Our extensive observations connected with the effects of meteorological conditions on plants have led us to examine hundreds of roots in different localities, and we have found this poor condition of the roots to be widespread and serious. The injury involving the larger fibrous roots was observed extensively four years ago, but that affecting the smaller fibrous roots was not noted in connection with the pine until last summer.

Sun Scald.

The trunks of many apple trees which were affected by sun scald four years ago may be noticed at the present time. Two years ago a great many apple trees again showed the effects of sun scald, which was in many cases followed by canker, and this is very noticeable throughout the State on those trees which have not been pruned. It affected only the lower, shaded limbs, however, and is of little importance, being scarcely perceptible in properly pruned and well-cared-for orchards. The sun scald of two years ago affected many of our wild plants, causing much injury to the wild cornels, particularly to *Cornus stolonifera*, Michx., and *C. circinata*, L'Her.

During the past spring practically every sycamore lost its leaves when they were half grown, from the same cause, and an examination of the young wood of the sycamores showed that all last year's growth was injured; but as the sycamore is a difficult tree to kill by defoliation, from whatever cause, buds were thrown out from the old twigs, and the trees subsequently bore a good crop of foliage. The sycamore often becomes defoliated in early summer from the effects of the fungus *Glœosporium nervisequum* (Fckl.) Sacc., but always succeeds in providing itself with new foliage in a short period of time. Sun scald is a common trouble, and can be easily produced in the laboratory. Our attention has often been called to the sun scald of apple trees, caused by banding with tarred paper, showing that tarred paper should not be used around apple trees without taking precautions.

Sun Scorch.

The past season has been very favorable for sun scorch, this trouble having been much more severe in the eastern part of the State, where the effects of the drought were more marked. Sun scorch is prevalent every summer on certain trees, especially those located in dry soil, and rock maples are peculiarly susceptible in this respect. This season the white pine also sun scorched badly, the injury appearing to be much more general than that which occurred three years ago, but less severe on the foliage, since in practically all cases the burning was confined to the apical portion of the needle, and seldom extended to the base. If the needles are not wholly destroyed, no great injury results, and a large number of the trees which were burned three years ago have entirely recovered. Should nothing further affect the pines, and the condition of the roots improves, the present burning will be scarcely perceptible one year from now, as it is a matter of general observation that many of the trees which burned this season commenced to recover a few weeks after being affected.

Strong, dry winds are important factors in producing sun scorch, and an excellent illustration of this may be found in the ninth annual report of the Hatch Experiment Station (pp. 81, 82); but, technically speaking, the cause of sun scorch is the exhalation of watery vapor from the foliage in excess of the amount of water supplied by the roots. Sun scorch is a common phenomenon, peculiar to many plants, and, while its occurrence on the pine appears to be new to most people, we have observed it for twenty-five years to a very limited extent. The cause of the recent sun scorch of the maple and white pine is to be found in certain meteorological conditions, but the immediate cause may be traced to the peculiarly dry winds of July, together with the inability of the roots to supply sufficient water. The effect of sun scorch is more marked on the western side of a tree or forest, — a fact which has been noted by various observers besides ourselves.

4. Premature Defoliation of Trees.

The premature defoliation of trees, which has been very common this season and which occasioned considerable correspondence, as usual, gives rise to much unnecessary anxiety. Among the many well-known causes of defoliation may be mentioned severe drought, and even excess of water may cause it. Elm trees, however, are likely to lose their leaves both in early summer and fall, and this is also common to other trees; but the loss of foliage in the case of the elm is seldom serious enough to cause alarm; and even the shedding of the twigs of the elm, which occurs to considerable extent, often periodically, generally causes little damage.

5. Asparagus Rust.

This disease has been more prevalent than usual the past summer in certain localities, but less so in others. It has in some places affected those beds which in ordinary seasons seldom show outbreaks except in the late fall. The rust occurred in a rather unusual form for this section, since as a rule the summer stage (uredospore), which causes practically all the injury, was checked, and as a result the fall stage (teleutospore) developed early in the summer. This often occurs on beds which never suffer materially from the rust, but it is the first instance noticed in this section of the uredospore stage being supplanted by the teleutospore stage in midsummer on beds which are usually infected with the uredospore stage, and which suffer more or less loss from such infection. This supplanting of the summer stage by the fall is an advantage to the crop, as the fall stage causes little damage, and there is not the slightest opportunity for infection during the summer, as the teleutospores do not germinate until they are given a resting period. Prof. R. E. Smith[1] has shown that this often occurs in California, attributing it to a lack of atmospheric moisture.

6. Asparagus Fusarium.

During the past few years our attention has been called to an apparently new fungous trouble affecting asparagus, which has appeared in some instances in the spring, attacking the fresh, marketable shoots. On one bed it occurred two years ago, but the owner has not been troubled with it since. In this case the young, tender shoots rotted off near the surface of the ground, and an examination of the soft rot in the tissue revealed that the asparagus shoots were infected with a species of fungus known as fusarium. Many instances of fusarium infection have also been observed by us later in the season on the mature stalks, the infected stalks being contorted in their growth and often split open, and an examination of these stalks always reveals a dense growth of this fungus.

7. Peony Troubles.

For two years we have had complaints in regard to a serious trouble of the peony, concerning which much has been written in the florists' journals. The disease is characterized by the dying of the plant to the ground, and an examination of the portion under ground usually reveals a decidedly bad state of affairs. In most of the specimens examined, the crown of the

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[1] The Water Relation of *Puccinia Asparagi*. R. E. Smith, Bot. Gaz., Vol. 38, July, 1904, pp. 19–43.

plant, which is located just below the surface, is more or less blackened and decayed, and often dead, the black areas and decayed spots frequently extending below the crown of the plant for some distance. Microscopic examinations of the rather limited material which we have had at hand have revealed no specific organisms associated with this trouble, although fungi, bacteria and eel worms are usually found in the decayed tissue, apparently as secondary factors or accompaniments of decay. In one instance plants were observed which had perfectly clean cavities in the crown, as though eaten out by some small animal; and in other instances the so-called club-foot or gall formation, containing eel worms, was noticeable on the roots, but these did not seem to be responsible for the trouble. Further investigations of this disease are at present under way.

8. Potato Diseases.

Potato foliage went through the season with comparatively little disease. There was no blight of any importance. Some potato crops always die down or mature earlier than others, which is due in part to the conditions under which they are grown, though it is often believed that this early maturity is caused by some blight. The abundance of rain in the fall, which followed the long drought, caused potatoes to rot badly in some cases, especially when located on low and not easily drained soil, but on the whole the season was favorable for potatoes, the dry summer holding in check certain fungi which are likely to be troublesome, especially during a wet summer. On some fields, late in the season, following the period of rain, a rather unusual outbreak of *Cladosporium fulvum*, Cke., occurred, although this fungus is usually confined to tomatoes in this section.

9. Experiments with Fungicides.

Some potato-spraying experiments were made on the station plots, for the purpose of testing and comparing certain spraying mixtures to discover their adhesive properties, as well as their value as fungicides. As there was little fungous infection on the potato during the summer, the deductions which were drawn from the various applications of fungicides are not of great value.

The plots selected were those which were being used in the agricultural department for testing the relative value of potash compounds,[1] and for our purposes five of these were used. With the exception of two plots, the standard Bordeaux mixture formed the basis of the fungicides, the regular 4 — 4 — 50 formula being used. The plots were tested as follows: —

Plot 1 was treated with Bordeaux and Paris green, 1 pound of Paris green being added to 50 gallons of the Bordeaux.

Plot 2 was treated with Bordeaux and "Disparene," or arsenate of lead, 5 pounds of "Disparene" being added to 50 gallons of the Bordeaux.

Plot 3 was treated with Bordeaux and sodium benzoate, 4 to 6 ounces of the sodium benzoate being added to 50 gallons of the Bordeaux mixture.

Plot 4 was treated with soda Bordeaux and Paris green, 1 pound of Paris green being added to the soda Bordeaux mixture.

The soda Bordeaux is made as follows: —

Soda (commercial lye),	2 lbs.
Copper sulfate,	6 lbs.
Lime,	½ to ¾ lbs.
Water,	60 gals.

The mixture was tested to insure its alkalinity, and the amount of lime was modified according to the strength of the lye.

Plot 6 was treated with copper phosphate and "Disparene." Copper phosphate is a compound prepared by the Bowker Chemical Company, and is being tested as a fungicide. Our formula is as follows: —

Copper phosphate,	5 lbs.
"Disparene,"	5 lbs.
Water,	50 gals.

The plots were sprayed July 6, when the sun was shining, in the order given in the outline, the ordinary barrel spray pump being used. No rain fell before the first observations were made on July 11. The potato bug and flea beetle were present

[1] See report of the agricultural department, p. 39.

in abundance before the plants were sprayed. The results of the observations of July 11 are given below: —

Plot 1. Bordeaux and Paris Green mixed: —

No live potato bugs found.

The flea beetles scarce.

The mixture colored the leaves well.

Plot 2. Bordeaux and "Disparene" mixed: —

No live potato bugs found.

Flea beetles scarce.

The mixture seemed to adhere rather better than the Paris green, and covered the plants more evenly.

Plot 3. Bordeaux and Sodium Benzoate: —

A few potato bugs found on this plot.

Flea beetles scarce.

Color not very strong.

The mixture adhered well.

Plot 4. Soda Bordeaux and Paris Green: —

No potato bugs found.

No flea beetles found.

No strong color shown on plants.

Plot 5. Copper Phosphate and "Disparene": —

No potato bugs found.

Flea beetles very scarce.

Mixture does not color plants to any appreciable extent.

Although careful observations were made from day to day on the general appearance of the field, and the presence and absence of bugs noticed, by the time set for a second spraying no material difference in appearance was noticeable. Without exception the plants maintained the same condition, *i.e.*, they were free from potato bugs and flea beetles. One plot, that on which sodium benzoate was used, did seem toward the last to have rather more flea beetles and potato bugs than the others, although these were not in sufficient numbers to do any but local damage. There was absolutely no sign of burning of the leaves or stems on any of the plots.

The field was sprayed as before for the second time on July 22. The night after the spray was applied it rained heavily, and most of the spray was apparently washed off; but when the field was examined on July 29 no potato bugs were found, and there was no sign of blight. There was no appreciable leaf burning except in a few isolated cases, and in all these the plants affected were small and weak, and had not made the growth of the others.

One week later the field was sprayed for the last time, as after this the plants became too large to be sprayed again. During the month of August the plants were inspected from time to time, but no late blight (*Phytophthora infestans*, (DBy)) occurred. In the first week in September, however, a disease appeared which seemed to make headway on some parts of the field, although of no general occurrence on potatoes. This was *Cladosporium fulvum*, Cke. A period of wet weather lasting about a week and a half occurred just after the Cladosporium was noticed, and under these favorable conditions the disease spread rapidly in some sections of the field.

No more observations were taken of the plots until September 16, when the field was again examined carefully, both with reference to the diseases present, the general appearance of the plots and the maturity of the plants. These results were the last taken before the potatoes were dug, and are given below.

Regarding the diseases present on the different plots treated with the spraying mixtures, it was found that plot 1 sprayed with Bordeaux and Paris green, showed the presence of both Alternaria and Cladosporium, although these diseases were found only in localized areas, and could not be considered as especially destructive to the plants. The Bordeaux and Paris green is productive of fairly good results, but does not prove to be so efficacious as some of the mixtures used on the other plots.

Plot 2, treated with Bordeaux and "Disparene," presented a better appearance than did plot 1, and showed very little Cladosporium or Alternaria. This was due to the fact that the mixture adhered to the leaves for a longer time, and was not so easily washed off as the Paris green-Bordeaux mixture.

Plot 3 was sprayed with Bordeaux and sodium benzoate, and the plants proved to be in exceptionally fine condition, practically no Alternaria or Cladosporium being found even on dead plants. This mixture, although not coloring the leaves to any appreciable extent, seemed to adhere better than any of the others, with the exception of that used on plot 4.

Plot 4 was sprayed with soda Bordeaux and Paris green, and when the observations were taken showed no Alternaria or Cladosporium, the whole plot presenting a good appearance. This mixture adhered to the leaves the best of any and possessed the advantage of not coloring the plants to any great extent.

Plot 5 was sprayed with copper phosphate and "Disparene," and was in very poor condition when examined. The whole plot was badly affected with both Alternaria and Cladosporium, and little good seemed to result from spraying with this mixture.

The following table shows the relative appearance of the sections of each plot: —

TABLE III. — *Showing the Relative Difference in the Condition of Each Plot, Sept. 16, 1907.*

Section.	TREATMENT.	PLOT 1. Bordeaux and Paris Green.	PLOT 2. Bordeaux and "Disparene."	PLOT 3. Bordeaux and Sodium Benzoate.	PLOT 4. Soda Bordeaux and Paris Green.	PLOT 5. Copper Phosphate and "Disparene."
Section 1,	No potash, . .	½ dead,	All dead,	All dead,	All dead,	All dead.
Section 2,	Kainit, . . .	¾ dead,	¾ dead,	¼ dead,	½ dead,	⅜ dead.
Section 3,	High-grade sulfate of potash.	¾ dead,	½ dead,	¼ dead,	¼ dead,	¾ dead.
Section 4,	Low-grade sulfate of potash.	½ dead,	½ dead,	¼ dead,	½ dead,	⅞ dead.
Section 5,	Muriate of potash, .	¾ dead,	¾ dead,	⅜ dead,	⅜ dead,	¾ dead.
Section 6,	Nitrate of potash, .	½ dead,	½ dead,	⅜ dead,	½ dead,	¾ dead.
Section 7,	Carbonate of potash,	¼ dead,	¾ dead,	½ dead,	½ dead,	¾ dead.
Section 8,	Silicate of potash, .	⅜ dead,	⅛ dead,	¼ dead,	¼ dead,	⅞ dead.

Of the different spraying treatments the copper phosphate shows the largest percentage of dying plants, and, as already stated, this plot was the most severely affected with fungi. The other plots which showed less infection were treated with Bordeaux mixture in some form of combination. The application of Bordeaux mixture is known to prolong the maturity of crops, and no doubt the difference in the maturity of the plots treated with the Bordeaux mixture and those treated with copper phosphate is due in part to the tonic effect of the Bordeaux. Too much reliance, however, cannot be placed upon these conclusions as they represent only one season's work, and the following summary must be interpreted with caution.

Summary.

I. Of the sprays used this year on the experimental plots, the soda Bordeaux and Paris green was the best. It adhered to the leaves the best of any used, it did not color the foliage greatly, and effectively prevented the plants from being injured by either fungi or insects. In mixing this spray, however, *great care should be taken to add sufficient lime to make the mixture slightly alkaline, otherwise serious leaf burn might result.*

II. Bordeaux and sodium benzoate ranked a close second in effectiveness, and hardly any discrimination can be made between the soda Bordeaux mixture and the benzoate mixture. This mixture colors the leaves scarcely at all, and adheres about as well as the soda Bordeaux. The sodium benzoate could be added in slightly larger amounts without injury to the plants.

III. Bordeaux and "Disparene" seemed to be productive of fairly good results, and held the blight and insects well in check. It did not, however, give such good results as the first two mentioned. It showed up well on the foliage, coloring it heavily, and it adhered well to the leaves.

IV. Bordeaux and Paris green did not seem to hold the diseases in check as well as some of the other sprays, and did not adhere as well to the leaves; nevertheless, it was productive of good results.

V. Copper phosphate and "Disparene" seemed to have no appreciable effect on checking the disease, and this year's results, at least, seem to indicate that it is not equal to other fungicides.

10. Influence of Various Potash Salts on Potato Scab (*Oospora scabies*, Thaxter).

In connection with the preceding spraying experiments on potatoes, observations were made on the occurrence of potato scab in the various plots treated with different combinations of potash.[1] As previously stated, there were five series, each containing eight plots, fertilized with seven different potash compounds, with normal or untreated rows between the ferti-

[1] See report of agriculturist, p. 39, for details as to fertilizer.

lized ones. Potato scab has been slowly working its way into these plots since the experiment was started a few years ago, although the seed potatoes were treated with the standard corrosive sublimate solution before being planted. Notwithstanding this, potato scab developed quite severely on some plots, and the following table shows to what extent. No stable manure has been applied to these plots, hence that source of contamination has been eliminated.

TABLE IV. — *Showing the Development of Scab on Plots treated with Different Potash Compounds.*

FERTILIZER USED.	Amount of Scab (Per Cent.).
No potash,	5.0
Kainit,	2.0
High-grade sulfate of potash,	1.0
Low-grade sulfate of potash,	1.2
Muriate of potash,	–
Nitrate of potash,	–
Carbonate of potash,	95.0
Silicate of potash,	3.0

The above estimates of proportion of tubers affected by scab is based upon observations upon the fourth and fifth series of plots. The relative abundance of the disease in other plots was similar, but the proportion of scabby potatoes was larger.

The results given in this table show that there is a marked difference in one instance of the development of potato scab which can be traced directly to the fertilizer employed. It should be noted in this connection that the results in the different plots are very uniform, practically all the potatoes in the carbonate of potash plots showing much scab, and it is quite evident that this fertilizer is favorable for the development of scab. It is also clear that the corrosive sublimate method of treating the seed potatoes, as well as any other similar method of treatment, is of little value when the soil conditions are especially favorable for the scab fungus. The muriate and nitrate of potash plots did not seem to have developed the scab, and undoubtedly much can be accomplished in holding the disease in check by applying fertilizers which are unfavorable to the growth of the fungus. Wheeler, Hartwell, Sargent and Towar,[1] who have investigated this subject, have shown that acid soils restrict, while lime, ashes, etc., increase, the amount of scab. Dr. Wheeler points out that sulfate of potash, kainit and muriate of potash, in connection with dissolved phosphates, etc., will benefit the soil and render infection less prevalent.

[1] *Cf.* various articles by H. J. Wheeler, J. D. Towar, B. L. Hartwell and C. L. Sargent, in Bulletin No. 26, 1893, No. 33, 1895, and No. 40, 1896, Rhode Island Experiment Station.

11. Investigations relating to Mosaic Disease.

G. H. CHAPMAN.

The Mosaic Disease of Tomato and Tobacco.

Work on this disease was taken up for the first time at the station in July, 1907; too late in the season to observe the seed beds and the transplanting of field-grown tobacco in its natural state. However, the work of the past year has been more in the nature of verifying the results obtained by other investigators than in research purely, so only a preliminary report can be made at the present time.

The disease occurs on several plants, but seems to be most injurious to tobacco, although it has been found that in the case of greenhouse-grown tomatoes a heavy pruning back will bring on the disease, and, as observed at this station, lessens production.

All investigators agree that the mosaic disease is a purely physiological one, but there seems to be much doubt as to whether it is infectious or contagious in character, or both. There also seems to be some difference in opinion as to the direct cause of the disease. In tomatoes it is always produced when the vines are heavily pruned, and in the work here it has been shown that it is connected in no way with methods of transplanting the young plants, and only results from subsequent pruning.

It has been found that tobacco is much more susceptible under conditions which tend to produce the disease than is the tomato. In the case of tobacco, A. F. Woods[1] found that when a plant was grown in soil containing small roots of diseased plants the disease always occurred sooner or later. In our

[1] Mosaic Disease of Tobacco. A. F. Woods, Bulletin No. 18, Bureau of Plant Industry.

observations on the tomato we have been unable to verify this statement, as in no case has the disease appeared when normal plants were grown in soil which contained roots of plants which had been badly diseased, and in the growing of tomatoes year after year in the station greenhouses there has never been the slightest evidence of infection arising from the soil.

In the case of tomatoes grown under glass the disease did not make its appearance when the plants were left normal, but occurred when the plants were pruned. These conditions held true for soils in which there were diseased roots, as well as for those in which tomatoes had not previously been grown.

In the coming year the work will be renewed, and the disease studied under field conditions in the case of tobacco, and experiments carried on to determine the possibility of its occurrence in the seed bed and also after being transplanted from the seed bed to the field. It is thought that the conditions under which the transplanting takes place may account for the presence of this disease in some cases. One case, at least, has come to our notice which seems to indicate that the disease may result from improper handling. In the particular case referred to, two lots of plants were taken from the same seed bed. One lot was well moistened before being removed, and the second lot was removed in a dry condition. The same machine planted both lots, and it was reported that at least 70 per cent. of the plants removed from the seed bed in the drier state became more or less diseased, while of those properly removed and carefully handled only two or three plants became affected. It has also been frequently observed, in connection with the transplanting of aster seedlings from the same bed under identical conditions, that one lot will show the "yellows" badly, and another lot scarcely at all when transplanted into different localities.

In connection with the field work, experiments of a more technical character will be carried on in the laboratory, with a view to ascertaining the effects which different enzymes (oxidase, peroxidase, catalase, etc.) found in growing plants have upon the production of the disease. Woods[1] infers that oxidase and

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[1] Mosaic Disease of Tobacco. A. F. Woods, Bulletin No. 18, Bureau of Plant Industry, United States Department of Agriculture.

peroxidase play an important rôle in the development of this disease; but in the work so far carried on in the laboratory at this station it seems more probable that catalase has more to do with the production of a diseased condition. This bears out Loew's[1] hypothesis to a great extent, as in the preliminary work here it has been found that catalase is present in far greater quantity in healthy plants than in diseased plants. However, this point cannot be considered proved, as enough work has not yet been done to warrant such a statement. The results so far obtained will be found in this report.

Description of Mosaic Disease on Tomato.

The appearance of this disease has been described by many investigators, and nearly all have described it in a similar manner, but more particularly with reference to tobacco than to the tomato. The general characteristics of the disease are the same for both plants, but some difference is found in its appearance in extreme cases on the tomato, as will be noted from the following description: —

In the first stages of the disease the leaf presents a mottled appearance, being divided into larger or smaller areas of light and dark-green patches. At this point, however, no swelling of the areas is noticeable, but as the disease progresses the darker portions grow more rapidly, while the light-green areas do not grow so rapidly, and leaf distortion is brought about. In the tomato the light-green areas become yellowish as the disease progresses, and in badly affected plants become finally a purplish-red color. This purplish coloration is found principally on plants which are exposed to strong light, but does not always occur, as it has been found that sometimes, even in badly infested plants, the disease may reach its maximum without showing any reddish coloration whatsoever. The reddish appearance is noticeable only on the upper surface of the leaf, and appears to extend only through the palisade cells. As yet no investigation has been made with reference to its character, but from its appearance under the microscope it is thought that it may be due to the breaking down of the chlorophyll granules, as a result of the diseased condition of the leaf.

[1] Catalase, Oscar Loew, Report No. 68, Department of Vegetable Pathology and Physiology, United States Department of Agriculture.

Under all conditions of disease, however, the leaves are much distorted and *stiff*, and often very badly curled, never possessing the flexibility of healthy, normal leaves.

The Growing of Plants used in Experiments.

As the mosaic disease seldom if ever occurs on field-grown tomatoes, and as these experiments were carried on in the greenhouse, a standard greenhouse variety of tomato, the Lorillard, was used in the work. This variety is of medium size, and possesses strong growing qualities.

The seed used was carefully selected and of uniform size, all being over 2.5 millimeters in diameter. The seed was first planted in drills in a seed plot in which no tomatoes had previously been grown, and which could in no way contain any roots, decayed or otherwise, of diseased plants. After the seedlings had reached a height of 4-6 centimeters they were transplanted to 4-inch pots, and then once more transplanted, when they had reached a height of 15-18 centimeters, to the boxes containing the coal ashes, mention of which will be made later, and to the benches into soil which had not previously produced tomatoes.

The plants transplanted to the boxes were used to ascertain the action of excess of various plant fertilizers on the production or intensifying of the disease after it had once been contracted. The plants transplanted to the benches were used for inoculation and various other minor experiments.

Action of Excess of Fertilizers on the Production or Intensifying of Mosaic Disease.

To test the action of excesses of various fertilizers on the pruned and unpruned tomato plants, a fertilizer containing all the necessary plant food for tomatoes was used. The fertilizing constituents in tomatoes, given in parts per thousand, are as follows:[1] —

	Parts.
Moisture,	940.0
Nitrogen,	1.7
Ash,	–
Potassium oxide,	3.6
Sodium oxide,	–
Calcium oxide,	.3
Magnesium oxide,	.2
Phosphoric acid,	.4

[1] Hatch Experiment Station report, 1902.

A fertilizer of the following composition was used, applied in the indicated amounts per acre : —

	Pounds.
Nitrate of soda,	400
Superphosphate of lime,	1,320
Muriate of potash,	280
Lime,	1,000

In order to be certain that the production or reduction of the mosaic disease was due to the excess of fertilizer which was added in each case, a growing medium was taken which contained little or no plant food. In this case pure anthracite or hard coal ashes, which had been sifted through a one-fourth-inch sand sieve, were used.

Five wooden boxes of the same dimensions (45 by 45 by 30 centimeters) were filled to a depth of 25 centimeters with the ashes; to this was added in each case the requisite amount of the complete fertilizer calculated from the above formula. Box 1 contained the complete fertilizer, and nothing else; to box 2 was added an excess of nitrates equal to that already in the fertilizer; to box 3 was added an excess of potash equal to that already in the fertilizer; to box 4 was added an excess of phosphate equal to that already used; and to box 5 was added an excess of lime equal to that already used, — so that the boxes contained : —

Table showing Contents of Each Box.

Here n represents the normal amount of fertilizer.
N represents the nitrates.
K_2O represents the potash.
P_2O_5 represents the phosphoric acid.
CaO represents the lime.

Number of Box.	Coal Ashes.	N.	K_2O	P_2O_5	CaO
Box 1,	n	n	n	n	n
Box 2,	n	n + N	n	n	n
Box 3,	n	n	n + K	n	n
Box 4,	n	n	n	$n + P_2O_5$	n
Box 5,	n	n	n	n	n + CaO

Two tomatoes were planted in each box, one being pruned and the other not. They were allowed to grow for one week, however, before the first pruning, then one plant in each box was cut back to a point about 2 centimeters above the first leaves. In from one to two weeks all the pruned plants showed symptoms of the disease on the new growth, and continued to show it throughout the growing season. None of the unpruned plants showed the slightest indication of the mosaic trouble at any period of growth.

There appeared to be no difference in the intensity of the disease in any of the boxes, and when the diseased plants in the boxes were compared with plants of the same age grown in soil and pruned back at the same time, no difference in intensity of the disease could be noticed, so it would appear from this experiment that *excess of plant food* will not produce or intensify the mosaic disease of the tomato, although it has been observed that an excess of nitrogenous fertilizers does intensify the disease in tobacco, as well as that an excess of lime tends to lessen it,[1] and there are characteristics displayed by plants resulting from overfeeding which resemble the mosaic trouble. In our experiments with the disease on tobacco these views have been borne out, and it has also been noted that the tobacco is far more susceptible to those changes which bring about the disease than is the tomato.

Catalase in Tomato Leaves.

Some leaves of a perfectly normal tomato plant were treated to ascertain the presence or absence of the enzyme catalase, which has been so well described by Loew,[2] as it occurs in tobacco. As only green tomato leaves were available, they were taken and ground up in a mortar with fine quartz sand and a little water. After the leaves were in this manner thoroughly disintegrated the mass was covered with a .2 per cent. solution of ammonium carbonate $(NH_4)_2CO_3$, and set aside for three hours in a room the temperature of which was 25° C. After standing for this length of time the mixture was filtered through a coarse filter, and the resultant mixture filtered again through a finer filter paper.

The residue, consisting of pulp and quartz sand, was allowed

[1] Mosaic Disease of Tobacco. A. F. Woods, Bulletin No. 18, Bureau of Plant Industry, United States Department of Agriculture.

[2] Catalase. Oscar Loew, Report No. 68, Department of Vegetable Pathology and Physiology.

to stand for a short time to thoroughly drain, and the filtrate was treated with dilute acetic acid 1 : 4. The filtrate was greenish in color, and when acted upon by the acetic acid a flocculent precipitate was obtained which was also greenish in color, — whether due to impurities or pulp is a question.

A portion of unfiltered juice was also saved for treatment. A diluted solution of commercial hydrogen peroxide (H_2O_2, containing 3 per cent. of pure H_2O_2) was treated with a small amount of the residue obtained from the first filtration. An abundant evolution of oxygen gas resulted, showing that catalase was present, in insoluble form, at least. The insoluble catalase has been called by Loew α catalase. As no other known enzyme will break down hydrogen peroxide (H_2O_2) in this manner, it is safe to say that catalase was present.

The first filtrate was added to a diluted solution of hydrogen peroxide, and a somewhat smaller amount of oxygen relatively was evolved. To the precipitate obtained by the acidification and precipitation brought about by the action of the acetic acid on the second filtrate was also added a diluted solution of hydrogen peroxide, and the amount of oxygen evolved was very small, only traces of the gas being found. As this precipitate contained presumably all the soluble catalase found in the leaf, it was shown that the tomato leaf contained very little soluble catalase. The explanation for the greater amount liberated from the first filtrate is that the filter was so coarse that some of the pulp containing the insoluble form passed through into the filtrate, producing an energetic evolution of oxygen. The soluble form of catalase is known and is described by Loew as β catalase.

In the normal condition the tomato leaf contains a large amount of the insoluble form and only traces of the soluble form.

After finding that catalase was present in the normal tomato leaf, a number of leaves of plants affected with the mosaic disease were treated in a similar manner, to determine whether the presence or absence of this enzyme had anything to do with this disease. The leaves of the diseased plants were treated in exactly the same manner as the leaves of the normal plants, so that there might be no chance for error due to treatment of the leaves.

Some leaves of a plant badly affected with the mosaic disease were treated in the manner previously described. In appearance the pulp and the filtrate were lighter in color than in the case of the normal plants, due probably to the fact that there was less chlorophyll in them than in the normal specimens.

When allowed to react with hydrogen peroxide (H_2O_2) it was found that both forms of catalase α and β were present, as oxygen was evolved from the solutions in sufficient amounts to be measured.

Since it was obvious that both α and β catalase were present in healthy and diseased plants, it was decided to take a weighed amount of healthy and diseased leaves and measure the oxygen evolved in a given time from a solution containing a known percentage of hydrogen peroxide. For this purpose 5 grams of healthy leaves were treated in the manner previously described, and the oxygen given off was carefully measured by an ordinary water displacement method. The soluble catalase was not precipitated, however, but the filtered juice was added in each case directly to the solution of hydrogen peroxide. The strength of solution used was as follows: —

To 120 cubic centimeters of pure distilled water was added 20 cubic centimeters of commercial hydrogen peroxide, making a solution in the proportion of 1 : 6. The pulp containing the insoluble catalase was added to this solution, and the amount of oxygen given off carefully measured. This was done both for healthy and diseased plants. The results obtained for the insoluble or α catalase are given below: —

Table showing Oxygen developed by Catalase in Healthy and Diseased Leaves.

	Time (Minutes).	1.	2.	3.	4.	Average.
Healthy leaves, ...	5	c.c. 90.00	c.c. 165.70	c.c. 147.30	c.c. 87.00	c.c. 122.50
Diseased leaves, . . .	5	34.75	80.50	65.48	21.60	50.58

From these results it may be safely stated that there is certainly a lack of insoluble catalase in leaves of the tomato which are affected with the mosaic disease.

To a watery solution of hydrogen peroxide of the same proportion as used above, *i.e.*, 1 : 6, was now added the soluble or β catalase extracted from normal and diseased plants. The results in this case indicated also that the leaves affected with mosaic disease were deficient in soluble catalase. The results obtained are tabulated below: —

Table showing Oxygen developed by β Catalase in Healthy and Diseased Plants.

	Time (Minutes).	1.	2.	3.	Average.
		c.c.	c.c.	c.c.	c.c.
Healthy leaves,	50	26.00	48.30	33.10	35.80
Diseased leaves,	50	14.40	23.70	27.40	21.80

The foregoing results show plainly that catalase is greatly deficient in both α and β form in leaves affected with the mosaic disease.

As catalase is possessed of the property of decomposing hydrogen peroxide, and as it is a well-established fact that hydrogen peroxide is highly injurious to plant life, and also that it may possibly be formed [1] as an intermediary step in the various metabolic changes in plant growth, it is an interesting problem to discover whether the lack of catalase is a prime factor in the production of the mosaic disease. Work along these lines will be continued, and the results announced in a future report.

12. Some Factors which underlie Susceptibility and Immunity to Disease.

The permanent existence of any species depends upon its capacity for adapting itself to its surroundings. Health and disease in organisms are intimately associated with environment; and heat, light, moisture, plant foods, etc., are important factors. An understanding of the optimum conditions necessary for the growth of a plant is of the greatest importance as regards its normal condition of health. The close student of physiology and pathology must always have in mind the perfect type of plant, that is, one possessing perfect health, otherwise his diagnosis may be of little value, and the cause of

[1] Erlenmeyer, Berichte der deutschen Chemischen Gesellschaft, 1877. (Notes by Loew.)

certain unfavorable symptoms may escape his notice. In the same way that a physician can diagnose a patient's condition by an examination of certain organs, or gain an idea of the state of his general health by considering various symptoms, can one familiar with the normal functions of a plant ascertain its condition by observing certain features which it may display, and then discover the cause of the trouble.

The highest conception of health and vigor in plants is brought to a realization through the remarkable skill of expert gardeners, and it is no exaggeration to say that this class of men possess the most profound knowledge of a plant's requirements and limitations. Those trained men who have made a specialty of greenhouse crops for years are unexcelled in their skill and knowledge of the plant's needs, and this is also true of many intensive agriculturists. Some of these specialists have gained remarkable insight into the nature of plant reactions, the slightest change which takes place in the plant organism being noticeable to them; but such a large percentage of this knowledge is intuitive or instinctive, as it were, that it cannot be conveyed to others. The best gardeners are in sympathy with all that pertains to the well-being of their plants, and they are continually observing each minute change which the plant may undergo, thus gaining a knowledge of the influence of the external factors which in any way affect the organism. A slight modification in the light intensity or in the temperature for even a brief period is sufficient to cause variations in the plant development which are discernible to the expert gardener. The conditions which both directly and indirectly affect a plant in respect to susceptibility to disease are various. A plant, both in its chemical and physical characteristics, is affected by light, heat, electricity, gravity and soil, moisture, air, biological relationships, etc., and in greenhouses by such factors as ventilation, air space, quality of glass, and in fact the simplest features connected with greenhouse construction. It is in a greenhouse that we gain the most insight into the relationship existing between the condition surrounding plants and their susceptibility to disease, for here the gardener has the environment largely under his control, and can therefore regulate the conditions to meet the requirements of his plants. The relation of external factors to plant diseases can be most satisfactorily studied in the greenhouse, because it is possible to modify and eliminate those which have a direct bearing upon disease, and in this way their true significance may be determined. When the conditions surrounding the plant are far from the optimum, injury and even death may follow. A stimulus which may prove beneficial under certain conditions may injure or cause the death of the organism under others; and it is only by possessing a knowledge of the optimum conditions for stimulation and by meeting the normal requirements of the plant that we can expect to obtain a perfect organism. Everything which has a bearing upon the development of the plant must be carefully considered if the perfect type is to be realized. These factors not only affect development, but have a fundamental bearing upon immunity; and if the environment can be controlled, disease can be controlled to a large extent. Even when it is not possible to modify the heat, light and moisture, as is the case out of doors, infection can be largely eliminated by making use of certain cultural practices; in fact, cultivation constitutes one of the most important factors in the control of disease.

Light affords a good illustration of the rôle a single factor may play in the configuration of plants. The physiological effect of light is to inhibit growth and to induce the formation of a firm texture of the tissue, On the other hand, lack of light stimulates growth, but plants grown in darkness are etiolated and lack firmness of tissue. There are many instances of the absence of light being responsible for serious troubles, and in others light undoubtedly exerts a detrimental influence. The tonic influence of the Bordeaux mixture in favoring the formation of chlorophyll and carbon assimilation in many plants would appear to be due to the screening or lessening of the light intensity. Sun scald, which occurs on various trees, is brought about by excessive light, as in the case with apple trees, which, when defoliated by the gypsy moth, usually die from the effects of sun scald. On the other hand, shading often causes sun scald by preventing the ripening of the wood.

There are apparently some cases, at least in greenhouses, of too intense light, or the conditions resulting from it, causing trouble to crops. In the northern latitudes many greenhouse crops do not obtain sufficient light during the winter months, and when cloudiness prevails it is with some difficulty that crops are matured without becoming diseased. All expert greenhouse men mature their crops when the weather conditions will permit, and not according to the calendar; in other words, it requires a certain definite amount of light, or so many light units, as it were, to mature a crop. The light in May, for example, is equal in intensity and amount to about twice that of corresponding periods of a day in November; consequently, it requires about twice as much time to bring a crop to the same degree of maturity in November as it would in May.

Lack of light is responsible for various mildews and leaf spots, top-burn or tip-burn, wilts, etc. Many of these leaf spots are seldom if ever found on plants to which sunlight has access. The Sclerotinia diseases of lettuce, water cress and parsley are likewise induced by crowding and shading, and light in such cases will prevent infection by the formation of resistant tissues. It is well known that absence of light causes the so-called "layering" of wheat and "damping off" of cuttings, and the mildews of various plants grown in the shade are too well known to need consideration,

The improper regulation of atmospheric moisture and ventilation is responsible for many fungous diseases, and the control of these factors is important in preventing the troubles. Among the mildews, Cladosporium can be entirely controlled by holding the moisture in the greenhouse in check, and by paying strict attention to proper ventilation and to normal light conditions. Many gardeners have succeeded in controlling the chrysanthemum rust by using proper precautions in regard to moisture.

A series of the most troublesome diseases common to cucumbers and melons out of doors — Plasmopara, Alternaria and Anthracnose — can be absolutely controlled in the greenhouse by paying attention to moisture, light and ventilation. The circulation of air, as well as light, has a marked effect upon the development of resistant tissues in greenhouse crops, and the control of moisture is necessary to prevent the germination of various spores which are likely to infect crops. It is well known that the tops of trees are less likely to become infected by fungi, owing to the smaller amount of moisture there than about the branches nearer the ground ; and asparagus plants when grown under trees or covers which protect them from the dew seldom show any indications of rust.

Too great a degree of heat and moisture in the soil gives rise to serious troubles, as may be seen in the case of Œdema of tomatoes ; and when seedlings are grown in soil that is kept too moist and at too high a temperature, they are likely to "damp off." The presence of water in a plant in excess of certain amounts is favorable to disease, as is shown in the carnation's susceptibility to rust ; for example, those carnation plants possessing the greatest amount of water in their tissues appear to be the most susceptible to rust. The stimulating effects of electricity, fertilizer and sterilized soil often prove injurious by developing too high a water content in the tissues, thus rendering them more susceptible to disease. Tillage, manuring, irrigation, mulching, etc., are important factors in securing vigorous plants, and go a long way towards rendering them immune to certain diseases. An excessive amount of moisture in the soil stimulates growth and often renders plants more susceptible to fungous diseases, and a lack of water has the same effect ; in fact, stimulation of various sorts may result in weakening a plant and rendering it less immune to disease.

The life history of an organism presents different stages of susceptibility or immunity to disease, corresponding to different stages of development ; for example, young plants may be more susceptible to certain diseases than older ones. Very young seedlings often fall a prey to the "damping off" fungus, but when they have reached a certain stage of development they become immune to fungi, and the younger and less-developed parts of mature plants are more susceptible than the older parts. Vegetative rest and overmaturity are also favorable to disease, while the conditions associated with isolation are unfavorable for infection. Weakened plants are more susceptible to disease than strong ones, and in most cases, if not all, vital depressions are the real causes of disease. Vital depressions are brought about by the abnormal conditions which modify and reduce the power of resistance, consequently the organism falls a prey to the ever-present germ.

The causes underlying susceptibility are much better understood than those of immunity. Why it is that the moment a plant becomes weakened various organisms attack it, is not fully understood. We have observed many instances of certain treatments weakening plants, and as a result it is surprising to note the number of organisms which always attack the plant a very short time afterwards. The changes which actually take place in an organism in a depressed condition are not known, but many of these may be of an abnormal chemical nature. It is possible that these abnormal chemical changes stimulate organisms to attack weakened plants; that is, the loss of immunity increases the susceptibility of the organism to disease, due to vital depressions in the plant, which may result in the giving off of substances that act as a stimulus and attraction to invading organisms. Briefly stated, susceptibility to disease may be associated with chemotactic irritability.

Some crops are probably rendered more susceptible to fungous diseases by cultivation. The limitations of forcing have undoubtedly been overstepped in some cases, and this is especially true of the carnation, which has been much troubled with the wet and dry stem rots since the modern methods of forcing have come into vogue.

In the case of outdoor crops, great differences exist in the environment, due to climatic influences. The conditions may be such that a disease constantly causes loss in one locality and scarcely any in another; and, while it may be necessary to spray for a trouble in one State, in others no attention need be given it. No doubt in some instances it would be wiser to devote one's energies to cultivation, as a means of preventing plant diseases, than to resort to the use of fungicides. Our most skilled agriculturists, such as florists and market gardeners, seldom if ever resort to spraying, and in greenhouse culture the use of fungicides is practically unknown. Certain crops are greatly benefited by being sprayed with fungicides; but, on the other hand, there are crops which have been sprayed for many years with little or no benefit as far as the control of pathogenic fungi is concerned, and the money spent for spraying would in such instances be more wisely used in methods of cultivation. Some of our best landscape gardeners have advocated that, if $25 were to be used in planting a tree, about $23.50 of it should be used for preparation; and such advice is based upon the best agricultural practices. If intensive agricultural methods were applied more often to the growing of plants, pathologists would have much less diagnosing of diseases to do.

Every influence which may in any way affect plants should be carefully studied. We should understand what influence the chemical, physical and biological properties of soil, manures, fertilizers, air drainage, etc., have upon susceptibility to disease. The plant organism is an extremely complex mechanism, very plastic and responsive, and is continually being acted upon by a number of forces or stimuli which in turn produce a series of self-regulatory and correlative reactions. Undoubtedly in the future the control of plant diseases will depend more upon breeding and cultural conditions than now; but for the present, spraying must be employed when practicable for the control of diseases until something better shall have been discovered.

REPORT OF THE ENTOMOLOGISTS.

C. H. FERNALD; H. T. FERNALD; J. N. SUMMERS.

Outline of Work.

The four divisions into which the entomological work of the experiment station is naturally divided — correspondence, experimental investigations, special research and publication — have each received their share of attention during the past year.

The correspondence has been as large in amount as heretofore. Many inquiries about many kinds of insects have been received and answered as fully as possible: and in this connection the printing of a number of circulars, treating of the insects most frequently asked about, has greatly facilitated the work, as a circular can be sent in a small fraction of the time necessary to write out the same information, besides giving an opportunity to send illustrations of the insects and of their work.

Experimental investigations during the year have been along numerous lines. Determinations of the resistance of different crops to fumigation with hydrocyanic acid gas have been continued, and are now complete for the cucumber, and similar tests for muskmelons are under way.

An extensive series of tests of different methods for the control of cabbage, turnip and onion maggots was also begun. The cabbages, being the first crop on which treatment was possible, were experimented with in nine different ways. Unfortunately, it soon became evident that no treatment of any kind would be needed, almost no maggots being present either in the check rows or in the field anywhere, so that the only data of any value which could be obtained were those relative to the cost of different materials and the ease with which they were applied, leaving the question of their relative efficiency for subsequent determination in other seasons.

Observations on the dates of appearance of the oyster-shell, scurfy and white pine scales have been made as usual, and should be continued for a number of years, to obtain reliable averages for use in spraying. Observations on the number of broods of the codling moth have also been continued, and a more extensive series of experiments with this pest is now being planned for next season.

In 1906 the "blight" caused a large monetary loss in the Connecticut River valley on the onion crop, and as this is caused by a thrips, studies of the best methods of controlling this pest were undertaken in co-operation with several large onion growers. The main difficulty in this work seems to be to devise a machine which will spray a number of rows at once in a sufficiently thorough manner to destroy most of the insects. This problem is now being worked upon, and with good prospects of success.

The number of new mixtures produced for use against the San José scale has necessitated many tests of these materials, some of which seem quite effective, though expensive, while others apparently are of no value. Thus far nothing tested at this station which is reasonable in cost has excelled the lime and sulfur wash, though a few trials of one substance are quite promising, and these will be continued during the spring of 1908.

Investigations on the work of cranberry insects and the best methods for controlling them have been continued in charge of a special investigator located at Wareham, and it is hoped to publish the results of this work soon as a bulletin. At the request of the Cranberry Growers' Association, sets of cranberry insects and samples of their work are being prepared, to be placed in different parts of the cranberry-growing region, where they will be most easily accessible for examination by growers.

During the summer the life history of the oriental moth was carefully studied, and all stages of its existence were described and photographed. In addition, a study was made of the local conditions where it occurs, and it was found that the limits of its distribution, as already published, though approximately correct, are not entirely so, the insect having been found in one or two directions beyond those limits. In most of the infested territory the brown-tail moth is abundant, and spraying with arsenate of lead was very general in that region last summer. The result was also to destroy large numbers of the larvæ of the oriental moth, the treatment being so effective that in August it was hard to find any of the caterpillars without making a prolonged search.

These facts indicate that this insect is not likely to become a serious pest. If it should become well established, however, in some locality where no attention is paid to insect pests, it is possible that it might cause considerable injury; but in such a case it is probable that a single thorough treatment there would be effective for several years. The Japanese name "ira-mushi," for this insect means "the nettle insect," and during the summer several reports of the nettling caused by the spines of the caterpillars were received, indicating that, if this insect should at any time become very abundant in an inhabited locality, the residents there might suffer some inconvenience from its presence.

Massachusetts is close to the northern limit of the distribution of some insect pests and near the southern limit of others. It seems probable that for some of these there are portions of the State where these pests may be of importance, while in others they will require no attention. It is important that the exact facts in this regard should be determined, and researches have been begun to ascertain the localities in which comparative immunity from certain pests may be expected. To obtain definite results on this subject will be the work of several years and much correspondence, but it is hoped that when they are obtained, directions can be prepared which will guide towns in different localities in making their annual appropriations for the protection of their trees, which will save many thousands of dollars.

Three bulletins on insects (Nos. 114, 115 and 116) have been published during the year, besides numerous circulars already referred to, these last being used only in answering correspondence. In addition, a number of other articles too brief for bulletin material or not adapted for a publication of this nature have appeared elsewhere, and several more are nearly ready for the printer.

Insects of the Year.

The year 1907 has brought many inquiries about different insects. As heretofore, however, the San José scale has been most prominent in the correspondence, followed closely by the oyster-shell scale, plant lice, — particularly the woolly apple louse, — the codling moth, the plum curculio as an apple pest, the elm-leaf beetle and the apple maggot or railroad worm.

The elm-leaf beetle, after several years of comparative unimportance, is again becoming a serious pest. In 1900 and 1901 it caused much injury in the Connecticut valley and in eastern Massachusetts, and in 1902 its work was also very noticeable. In the spring of 1903 the beetles were abundant, large numbers of egg clusters were found, and there was every promise of another year of serious injury. During May and June, however, there was a drought so marked that grass dried in the fields and the leaves of the elms became hard and tough and many fell off. It was noticed that many of the egg clusters of the elm-leaf beetle failed to hatch under these conditions, and that the young larvæ in many other cases seemed unable to bite into the tough, dry leaves, so that the work of this insect in 1903 was unimportant. The following winter was unusually severe, but whether this was also a factor in the result cannot be stated. Whatever the cause, however, few elm-leaf beetles were present in 1904, 1905 and 1906, though in the year last named they were increasing in abundance; but last summer (1907) they had become quite plentiful, at least in certain localities, and it is probable that they will be as injurious as formerly in a year or two, unless climatic factors again cause their destruction.

Just how far the drought of 1903 was responsible for the destruction of these insects it is of course impossible to say; but the abundance of unhatched egg clusters and the evident struggles of the tiny grubs to break through the unusually toughened epidermis of the leaves during that period are very suggestive.

The appearance of the leopard moth (*Zeuzera pyrina*) in and around Boston during the past year adds another important insect to the list of pests with which Massachusetts must deal. This insect has been quite abundant around New York City for some years, but has not been reported from this State. As a borer in shade trees it is a serious pest, and its presence must hereafter be taken into consideration by our city foresters and tree wardens.

The brown-tail moth has continued to spread over the State, but in those localities where it has been longest present it seems to be becoming less serious and more generally attacked by disease. Whether this condition will be permanent or is only temporary cannot be determined now, but its permanency is greatly to be desired.

The presence of the San José scale in the Housatonic valley has been suspected for several years, simply because there seemed to be no reason why it should not be present there. Specimens of this scale from several localities in this region, received during the past season, demonstrate its presence there, leaving only the higher parts of the Berkshire hills and the northwestern corner of the State as localities from which it has not as yet been reported, and time will probably add these portions of the State to the list of infested regions.

The marked decrease in abundance of root maggots and cut worms this year should be noted, while the spruce gall louse, squash bug and several kinds of caterpillars, all common pests, appear to have been unusually abundant; but on the whole the year has been without a serious insect outbreak of any kind.

REPORT OF THE VETERINARIAN.

JAS. B. PAIGE, D.V.S.

Outline of Work.

The work in the veterinary department of the station naturally falls under one of the following divisions: correspondence, examination of specimens, and original investigations. These merge so much one with the other that they are by no means as distinct as the divisions would seem to indicate. It not infrequently happens that through correspondence attention is called to the existence of a peculiar disease among farm animals. Specimens are asked for, and forwarded for examination, which sometimes afford material for original investigations.

Correspondence.

During the past year letters have come to hand from people in every part of the State, asking for information regarding the sickness of individual animals, or perhaps regarding a disease that has appeared in a herd or flock, affecting many animals. Of necessity it is impossible to make a correct diagnosis in every such instance, from the description of the case as detailed by the correspondent. In other instances the symptoms are so accurately given and of such a character as to enable one to diagnose the case with certainty, and advise a specific course of treatment. The correspondence work carried on with those living in rural sections, where no qualified veterinarian is accessible, has proven of such benefit to the farmers as to warrant its continuance, notwithstanding the difficulties that are encountered in arriving at definite conclusions as to diagnosis and treatment. When it is impossible to give definite directions for the treatment of an individual animal, it is possible from the symptoms enumerated to recommend a line of treatment, or general directions can be given which when carried out make it possible for the stock owner to pursue such a course as to prevent the spread of the disease to other animals exposed, or to prevent its recurrence.

Examination of Specimens and Original Investigations.

For many years it has been the practice of the veterinarian of the college to examine material from sick or dead animals, and to report the findings to the one sending the specimen, and advise a line of treatment for the individual animal or protection of the remaining animals of the flock or herd.

From an examination of such specimens as have been sent in during the past year, a diagnosis has been made of nodular disease of sheep, caused by the parasite œsophagostoma Columbianum, enterohepatitis of turkeys, verminous bronchitis of sheep, fowl cholera, swine plague and other more common diseases of a less serious nature. Through correspondence and the sending of specimens a very interesting and quite uncommon disease of poultry in this country was brought to the attention of the department.

In January of the present year there arrived at the department by express a dead fowl, which upon post-mortem examination exhibited some of the lesions of European fowl cholera. Microscopic examination gave support to that diagnosis. To confirm the same, a pigeon was inoculated with a small quantity of blood from the heart of the dead fowl. After the lapse of about twelve hours the inoculated pigeon was found dead. A microscopic examination, together with culture tests, demonstrated the presence of the fowl cholera organism in the blood. Subsequent inoculations and examinations gave similar results.

Considering the seriousness of the disease, its rare occurrence in this State, together with the possibilities of its rapid distribution among flocks of poultry, through sale of birds and otherwise, a visit was made to the farm from which the specimen had come.

It was found that about two hundred birds were kept by the poultryman, in two different flocks situated some fifty feet apart. About one-half of the fowls had been raised upon the farm the previous summer. The remainder of the flock, consisting of fowls and chicks, had been purchased of a dealer in live poultry the previous November. At this time all the birds raised and purchased seemed to be in perfect health. The history of the outbreak is briefly as follows: —

About Jan. 1, 1907, one morning the poultryman found, upon going into the house containing the purchased stock, a dead bird upon the dropping board. No sick fowls had been noticed the day previous. During the next two weeks several dead birds were found under conditions similar to the first. Few or no fowls of the flock exhibited symptoms of sickness at any time during the existence of the trouble. The loss continued, however, up to the middle of January, when the specimen was sent to the station. The total loss amounted to about twenty per cent. of the entire flock. One morning three dead birds were found under the roosts. At no time did the disease appear among the fowls raised upon the farm. This is probably to be accounted for by the fact that the infectious material was brought on to the place by the purchased stock, and that the two flocks were kept entirely separate. As soon as a diagnosis of the disease had been made, the poultryman was advised of the contagiousness and seriousness of it, and the possibilities of its spreading to other flocks in the neighborhood. He showed a willingness to do all in his power to eradicate the disease as soon as possible. At an early date all the remaining birds in the infected house were destroyed, the house thoroughly cleaned, fumigated and sprayed with a disinfectant solution. The treatment was so heroic and so faithfully carried out that there has been, so far as known, no recurrence of the trouble.

On April 18, 1907, a dead fowl from a farm on the opposite side of the street to the one where fowl cholera had existed was sent to the station.

An autopsy, supplemented by inoculation experiments and microscopic examinations, resulted in a diagnosis of fowl cholera, identical in every respect with that found to exist in the fowls kept on the adjoining farm. There were from four to five hundred birds on the place. A part had been raised on the farm, a part purchased of itinerant dealers in live poultry. The fowls were divided into two lots. About one hundred had the run of a large, dry, open barn cellar; the remainder were kept in a single long poultry house, divided into sections with partitions of wire netting. Both lots were allowed free range, all mingling together in one flock during the day.

It was learned from the owner on April 27 that the two weeks preceding the date of sending the dead fowls to the station (April 18), between fifty and sixty fowls, a part from each flock, had died very suddenly. It was also learned that during the winter of 1906 about one hundred and twenty-five birds had died from flocks kept in the poultry house and barn cellar during that winter. No cause was found to account for this large mortality. Taking into account the history of the case and the symptoms exhibited by the birds as given by the owner, it seems probable that the loss in 1906 was also due to fowl cholera. There is no positive proof that this was the case.

It was reported by the owner of the flock in question that his birds frequently came in contact with fowls kept on the opposite side of the street, and that individuals from both flocks ranged over the same ground.

In dealing with the last and larger flock, circumstances did not seem to warrant the application of the line of drastic treatment that had been carried out with the flock dealt with earlier in the year. Deaths had occurred among fowls kept in the poultry house and in the barn cellar; all had run together, when the weather permitted their being outside the buildings, and it seemed certain that the infection had become widely spread about all parts of the farm in the immediate vicinity of the buildings.

To arrest the spread of the disease, the owner was advised to thoroughly clean all parts of the buildings with which the fowls had come in contact, including a removal of the surface soil from the barn cellar and pens in the poultry house. He was further advised to follow this cleaning with a liberal application of a coal tar disinfectant and a fresh lime whitewash. As a further precaution against the spread of the infection through the medium of food and water contaminated with infectious fecal matter, specially constructed automatic feed boxes and drinking fountains were recommended. In addition, it was suggested that from five to ten grains of permanganate of potash be added to each gallon of drinking water, the water to be supplied fresh twice daily, and kept as free as possible from organic matter, which destroys the antiseptic properties of the potash salt. These measures, supplemented by frequent cleaning of houses, disinfection of fæces, etc., seem to have completely stamped out the disease, as nothing has been learned of its recurrence.

Judging from the reports that have been made of the few previous outbreaks of fowl cholera that have occurred in this country, it would seem that the two in question have been of a mild type, for in each outbreak previously reported the spread of the disease has been much more rapid and the mortality greater, amounting in some instances to one hundred per cent., as is frequently the case with the outbreaks in Europe. The successful treatment adopted in dealing with the second case, which consisted of mild measures, also tend to show that the disease was not of that virulent nature frequently met with.

Considering the few outbreaks of fowl cholera that have occurred in this country, and the benefit to be gained from knowing the source of the infection in combating this disease, it is to be regretted that the source of the contagion in the cases under consideration could not have been determined. It seems fair to conclude that it must have been introduced on one of the farms through some of the fowls purchased of the traveling dealers in live poultry.

Another interesting and, so far as can be determined, new disease for poultry was brought to the attention of the department through a communication from a poultryman on the Cape in the summer of 1906. An investigation of the disease was begun on June 27 of that year and concluded in October of the present year. During this time a series of experiments have been carried on at the college in conjunction with those conducted at the farm.

The part of the farm given up to poultry culture consisted in the main of a sand plain. A portion on which the chicks were kept consisted of pure white quartz sand, and was devoid of vegetation except for an occasional weed growing upon it. This locality had many years previously been the site of salt works.

The present owner had built upon this location a poultry plant with a capacity sufficient to handle from fifteen hundred to two thousand birds. This plant consisted of poultry houses, incubator cellar, brooder houses, coops, etc. Everything about the place, including equipment, was of the latest pattern and of modern construction. The practice was to hatch chickens in incubators and brood them under hens and in brooders. The hens with chicks were kept in coops placed some distance apart in yards. Several small yards were fenced off with wire netting, each of which contained a brooder of sufficient size to accommodate from fifty to seventy-five chicks. The disease never made its appearance among any of the adult fowls or any of the young chicks except those brooded in brooders. Those kept with hens in individual coops never contracted the trouble. The mortality among the brooder chicks usually ranged from ninety to one hundred per cent. The loss of from three to five hundred in a season was not an uncommon occurrence. It was extremely rare that a chick once attacked ever recovered. In some lots a few escaped contracting the disease, while others of the same lot succumbed to it. It usually attacked chicks at the age of three weeks, although those older or younger than this were not exempt.

The first appearance of the trouble was characterized by the development of large serous or water blisters on the front and upper parts of the featherless portions of the legs and feet. After a period of twenty-four to forty-eight hours the blisters would rupture and the serum escape. Frequently the affected parts would be rubbed with the head, and as a result the featherless parts of the head would become affected in a similar manner to the feet and legs. An extension of the disease about the head invariably led to an affection of the eyelids, which would become fastened together by the sticky exudate. The ball of the eye was not involved. In some instances the head would first become affected, later the feet and legs. Occasionally it was found that the head or the feet alone would be the only part involved. So far as known, the posterior part of the leg or parts of the body covered with feathers never became affected. After rupture of the blisters and escape of their contents the surface skin became dry and shriveled, after a time becoming detached, leaving behind the moist underlying vascular tissues. These soon become covered with soil and encrustations of tissue and serum. Forced removal of these crusts was followed by capillary hemorrhage and the formation of new crusts. A shedding of the crusts frequently occurred as the disease advanced. As a final result, all parts of the soft tissue of the feet were destroyed or modified to such an extent that the toes became bent upward, and the foot deformed so that only the ball of the foot would come in contact with the ground when walking was attempted. In addition to the local lesions, there were symptons indicating a considerable degree of constitutional disturbance. Nutrition seemed at a standstill. Growth was arrested, although there was a disposition to eat and drink. The closing of the eyelids often made it impossible for the chicks to take food or water, even though they were disposed to do so. When the lids were separated the birds usually ate and drank ravenously until they became filled.

Numerous remedies had been employed for the treatment and prevention of the trouble, but to no avail. The disease made its appearance in each lot of chicks shortly after they were placed in the brooders.

It was the opinion of the poultryman that the soil contained some poisonous irritating substance that was accountable for the trouble. Why it should appear in brooder chicks and not among those brooded under hens he was not able to explain. To settle this matter a sample of soil was submitted to chemical analysis, but nothing of an irritating or poisonous nature was found.

The general course and character of the disease seemed to indicate that it was the result of the local action of something. It was suspected that it might be due to the heat from exposure to direct sunlight. Experiments were made upon chicks by the use of a lens to concentrate the sun's rays upon the legs and feet, and it was found possible to produce upon experimental chicks lesions identical with those found upon chicks brought from the yards, even to the extent of producing a slight deformity of the toes, due to the contraction of the tendons and the cicatricial tissue. An attempt was made to rear feathered-legged varieties of chicks upon the same ground where there had been the greatest mortality, but owing to some mishap in connection with the incubation of the eggs, the work along this line was not completed. It is hoped to carry out this detail at a later date.

As a practical remedy for the trouble this poultryman has had to contend with, it was suggested that all chicks be removed to and raised upon an adjoining piece of ground sufficiently fertile to support vegetation, that would protect the featherless and tender portions of the body from the heat of the sun.

During the past summer this suggestion has been complied with, with the result, to quote the owner's own words, under date of Oct. 4, 1907: "That so far this season I have not had a single case of sore head or feet, such as you know of, among my chicks."

At present a series of experiments is being carried on to determine the effect of poisons, used in tree-spraying work, upon animals consuming forage grown beneath the trees.

REPORT OF THE METEOROLOGIST.

J. E. OSTRANDER.

In meteorology, where the work is in a large degree essentially that of observation and tabulation, the records must be continued from year to year without material change, if the results are to be of value for the purposes of comparison. As the length of time covered by the records increases, the data become more valuable, and the mean climatological conditions can be determined with constantly increasing accuracy.

During the past year the work of this division has been a continuation of that of previous years, and no material modification has been made. Although efforts are constantly made to increase the precision of the records, the general form and range remain unchanged.

The semi-daily observations, at 8 A.M. and 8 P.M., have been taken regularly, and the results transcribed in the permanent record book. Many records from the self-registering instruments have also been entered, to keep them compact and accessible. The usual monthly bulletins, giving much of these data, have been printed on the first of each month. These are now mailed from the director's office instead of from the printing office as heretofore, which involves a little loss in promptness of distribution. The December bulletin will contain a summary for the year, instead of the usual remarks.

The local forecasts have been received by telegraph from the section director of the United States Weather Bureau, at Boston, and the signals displayed from the flagstaff on the tower. This division has co-operated with the section director in furnishing the usual voluntary observer's reports for each month, and the snow reports during the winter season. The horticultural division has consented to keep a phenological record during the growing season for the use of this division, and a copy is furnished the section director at Boston.

The old thermometer shelter on the campus has been replaced by a larger and more convenient one, and an underground lead-covered cable placed for the purpose of providing an electric light in the shelter. A second underground cable is in place for connecting the tipping-bucket rain gauge with the recording instrument in the tower. A specially designed cover for the man-hole of the heating system, which is near the rain gauge, has been secured. It is proposed to place the rain gauge on this cover in such a manner that the heat from the man-hole will melt the snow which falls in the gauge, and thus furnish a precise record of the time of the beginning and ending of snowstorms.

A maximum thermometer of standard pattern is the only addition to the instruments made during the year.

No change in the personnel of the observers has been made during the year.

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